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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

The Lighting of Rifle Ranges.

This number contains the ***Report of the Council*** for the Session December 1914—May 1915, and the complete discussion on ***"Some Points in connection with the Lighting of Rifle Ranges,"*** opened by Mr. A. P. TROTTER at the Annual Meeting of The Illuminating Engineering Society on May 18th.

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EDITORIAL.

The Lighting of Rifle Ranges.

With the Annual Meeting, held on May 18th, the Sixth Session of the Illuminating Engineering Society has come to an end. Readers will find in the Annual Report (see pp. 245-249) a summary of this year's activities, and will readily appreciate the exceptional circumstances by which the Council has been faced in successfully maintaining the work of the Society.

Some important developments of the Society's work have been inevitably postponed, but it was felt to be essential to maintain the continuity of the movement and to select for discussion subjects of special interest at the present moment.

The discussions at previous meetings on such subjects as Searchlights and Visibility brought home to us the close connection between methods of warfare and problems of vision. Before an enemy is attacked his position and strength must be located. Acuteness of vision and instruments for aiding the eye, therefore, play an important role in modern military opera-

tions, and we find that many principles in connection with the use of artificial light in times of peace have also important applications in time of war.

The question of the Lighting of Rifle Ranges, discussed at the Annual Meeting, is an excellent instance of this. At the very outset we are faced by the effect of peculiarities and imperfections of the human eye, and the experience of members like Dr. Ettles who, besides having a special knowledge of this subject, are acting as instructors at rifle ranges, is of great assistance. At the present time many of our members have joined Volunteer Defence Corps and have thus a double interest in the lighting of ranges. The question is by no means so simple as would at first sight appear, and in view of the large number of artificially lighted ranges that are springing up all over the country, the need for some commonly accepted system of illumination is evident. As a preliminary to the discussion we followed the plan, which has proved very useful on previous occasions, of preparing a list of queries to serve as a basis for consideration. These queries were circulated among a considerable number of instructors of musketry and others likely to be interested. Mr. A. P. Trotter, who kindly undertook to open the discussion, as well as other speakers, makes frequent reference to these questions.

Many of them require further study but it seemed desirable to indicate those on which fair agreement has been reached, and we have accordingly prepared a short summary of the views expressed thereon, which will be found on p. 282.

Mr. Trotter has dealt with the subject in a very instructive and interesting manner, describing some of the special difficulties which he has experienced in becoming a marksman. He points out that a considerable section of the people who are interested in shooting in connection with Volunteer Corps, &c., have more or less defective vision, and for them the method of lighting is of particular importance. Although Mr. Trotter tells us in his modesty that almost everyone who took part in the discussion had a larger experience in shooting than his own, we are pleased to record that since the date of the meeting he has passed the tests for the " marksman class " (the highest class) of the City of London National Guard Volunteer Corps. This is surely the reward of perseverance and the result of a scientific attempt to solve some of the problems involved.

Mr. Trotter's opening remarks gave rise to an interesting discussion, and were followed by useful and elaborate contributions by Mr. A. Blok, Mr. J. G. Clark, and others, summarising the results of their tests on various ranges in and around London. We have also been privileged to receive contributions from the Commandants of the Royal School of Musketry at Hythe and of the Royal Marines, Deal, the latter being a succinct reply to the series of questions submitted. We take the opportunity of also thanking the Hon. Secretaries of the various rifle clubs who so kindly granted permission for their ranges to be visited for the purpose of this discussion, and gave facilities for measurements of illumination and photographs of the

ranges to be obtained. As it is hardly possible at the present stage to give a definite reply to many of the points raised, we do not for the moment propose to do more than give the general trend of the discussion. Generally speaking, the methods of lighting on the ranges visited in London, although capable of improvement, are mainly satisfactory in some important respects. In most of the ranges described the illumination on the targets was considered sufficient, and the lamps were adequately screened from the eyes of the marksman. We have, however, heard of other cases in which targets have been insufficiently lighted by unscreened dirty electric lamps or untended flickering gas jets, and it need hardly be said that in these circumstances good shooting is not to be looked for.

An important matter, which requires somewhat fuller inquiry before a definite reply can be given, is the desirable intensity of illumination on the target. The general opinion of those who have tested this point would seem to be that 10—20 foot-candles is ample, that below 5 foot-candles is hardly enough, and that values much above 20 foot-candles are apt, under certain conditions, to give rise to glare. It may come to some people as a surprise to learn that it is possible to overlight a target, but there is good reason to believe that this is so. If the target is too bright it may be difficult to see the bull or the sights distinctly, and there seems to be a certain " glaring " effect.

It goes without saying that the sources of light illuminating the target should always be screened from the eyes of those shooting, otherwise they would dazzle the marksman. But some difference of opinion has been expressed as to the desirability of leaving the firing point in complete darkness. Mr. Trotter and others consider that the violent contrast between the bright target and the adjacent darkness may be trying to the eye and prejudicial to acuteness of vision ; also unusual conditions of this kind may give rise to a specialised type of marksmanship hardly applicable to service conditions. In conjunction with Mr. Brazil, Mr. Trotter has devised an ingenious way of avoiding this extreme contrast ; in this way one approaches outside conditions more closely, and it is suggested that a certain amount of light from well-screened lamps might be allowed at the firing point.

This would enable the instructor to watch the men firing, and to some people the presence of this illumination would be of assistance in aiming. The question of the type of targets to be employed, and the best background is a somewhat debatable one. If pictorial targets are used the *colour* of the light should receive attention. An old and dirty electric lamp, giving a very yellow light, may make it difficult to distinguish objects (such as a man in khaki, shown in the picture). Possibly for this work lamps of the " artificial daylight " variety would be helpful. The question of the functions of miniature ranges, like the much discussed matter of the use of aperature sights, hardly falls within the scope of this editorial. We think, however, that a good case has been made out for closer investigation of the lighting conditions which are most desirable for shooting on miniature ranges, and the matter might now be taken up by a Joint Committee composed of members of the Illuminating Engineering Society and representatives of Rifle Clubs. It should not be difficult to reach agreement on fundamental points and to draw up a simple lighting specification, which would be a useful guide at the present moment, showing how the desired conditions of illumination may best be realised. Miniature ranges have come to stay, and with a view to the future it is desirable to standardise the essential conditions as far as possible.

Co-operation for the National Welfare.

Since the war began there have been many instances of combination between various interests for the national welfare. We have now a Coalition Government. The technical resources of the nation are being more completely organised, and we may hope that before long national organisation will be placed on a better basis. It is idle to regret lost time, and we are all aware that there is still great room for improvement. There is, however, no need to be discouraged. These defects can and will be made good if only the authorities resolve to utilise to the full the scientific and technical ability available.

An instance of this much needed co-operation was afforded by the recent joint meeting called to discuss the coal situation, at which Sir Corbet Woodall represented the gas industry and Sir John Snell the Institution of Electrical Engineers. To those in the engineering profession it has been recognised for some time that the coal supply was a vital problem. The non-technical public can hardly realise how a shortage of coal affects every branch of industry. In a recent paper before the Royal Society of Arts, Mr. H. M. Thornton gave a graphic account of the many technical applications of gas in the making of munitions, in heating forges and furnaces, drying and heating processes, &c. The writer, from his own experience, can confirm the great utility of gas as a lighting and heating agent.

Equally important are the needs of the electrical industry. The rapid extension of factories now engaged in Government work depends on their equipment with an adequate supply of gas and electricity as well as appliances for lighting and heating.

We are glad to see that the importance of the matter is receiving attention from the Authorities. Following the joint meeting referred to above a conference with Members of Parliament was held at the House of Commons on June 9th, and it is hoped that this will lead to better facilities being given for the supply of coal to the great national industries.

We have also to note the issue of the preliminary report of the Coal-Mining Organising Committee appointed by the Home Office on February 23rd last. The Committee consider the possibility of suspending the Eight Hours Act, and, among other suggestions, the public are reminded of the desirability of economising in the use of light. We of course agree that in times like these people should be particularly careful to avoid waste by burning unnecessary lamps. One of the chief effects of the illuminating engineer is to prevent such waste by the judicious placing of lamps and the use of efficient appliances for distributing the light where it is mainly needed. On the other hand we think it should be recognised that abundant illumination in the factory is not a luxury but an absolute necessity, if good work is to be done and an increased output secured. Those engaged in attending to the lighting of factories are surely doing important and highly necessary work at the present moment.

As a second instance of co-operation we may take the approved scheme for establishing central munitions works in the metropolitan area, so that the workshops and stations of the various companies and authorities interested in the supply of light, power and water, can be utilised for increasing the supply of munitions of war. We are glad to note this new instance of concerted action on the part of gas and electric interests, and we feel sure that during the critical months before us, there will be many other instances of such beneficial co-operation.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL GENERAL MEETING.

(Held at the House of the Royal Society of Arts, London, W., at 7.30 p.m., on Tuesday, May 18th, 1915).

THE Annual Meeting of the Society took place as stated above, THE PRESIDENT (Sir William Bennett, K.C.V.O., F.R.C.S.) being in the chair.

The Minutes of the last meeting having been read the Hon. Secretary announced the name of the following new applicant for membership :—

Smith, Chas. Abbots — Fixture Designer, 15, Baring Road, Addiscombe, Surrey.

The names of applicants announced at the last meeting* were read again and these gentlemen were formally declared members of the Society.

The Hon. Secretary then read in abstract the Report of the Council for the past Session. (See pp. 245—248).

The president said that the Report must be regarded as a very satisfactory one in the circumstances. It contained a record of a great deal of work, carried out in a very energetic manner, and there was good promise for the future.

Mr. F. W. GOODENOUGH (Chairman of Council) proposed the adoption of the report. It was, as the President had said, a really remarkably satisfactory report considering the very exceptional circumstances that had prevailed during the session. The Society could congratulate itself that it had been able to do some useful work in the present national crisis. The labours of the Home Office Committee on factory lighting would also form a monument to the usefulness of the Society, which had taken a prominent part in bringing about the holding of that inquiry and the carrying out of it.

He had pleasure in proposing :—

"That the Report of the Council for Session December, 1914—May, 1915, be formally adopted by the Society."

Mr. A. P. TROTTER seconded the adoption of the report. It should be a source of great satisfaction to the members to find the useful work of the Society increasing in the way it was. It had been predicted by some people when the Society was first formed,

* *Illum. Eng.*, Lond., May, 1915, p. 209.

that there would not be enough subjects to go round, and that they would be exhausted in two years and then the Society would be wound up. On the contrary, however, not only had they found fresh subjects but on the present occasion, when the whole of our lives and thoughts had been diverted by the war, the Society had been able to have three meetings devoted entirely to war subjects, which, perhaps, would not have occurred to them in more peaceful times. When those times came again he was sure the activities of the Society would be renewed in the directions which had proved so useful hitherto.

The motion was then put to the meeting and declared carried unanimously.

Mr. J. F. CROWLEY then proposed :—

"That this meeting extends a cordial vote of thanks to the President, Council and Officers for their efforts on behalf of the Society during the past twelve months."

The Society in his opinion, had placed illumination for the first time in this country on a scientific basis, and he wished to mention that, because many of the present officers were responsible for the initiation of the Society. It was also very much indeed to the credit of the officers that they had proved themselves so adaptable in present circumstances. Most of the societies that had had to continue in these strenuous times had found it very difficult to interest their members, but in the case of this Society, the officers had met the strange conditions in a very remarkable way. Papers were read on such subjects as searchlights and the lighting of rifle ranges—subjects of great public interest in the present circumstances. A debt of gratitude was due to the President, Council and officers for the manner in which they had maintained the traditions of the Society.

Mr. M. FOULDS seconded the resolution which was put to the meeting and carried unanimously.

THE PRESIDENT expressed his thanks for the generous way in which the resolution had been carried. He was sure that all the officers had felt the greatest possible pleasure in doing their work for the Society, and he was only sorry that he himself, owing to circumstances connected with the war and other things, had inevitably been prevented from being present as frequently as he would have liked.

Mr. L. GASTER (Hon. Secretary) also thanked the members on behalf of the officers for the vote of thanks. It was a pleasant task to carry on the work of a Society like this when all the members so cordially supported the Council and officers, and this work would be continued in the future so long as the assistance of the members was given as it had been in the past.

In conclusion the following resolution was moved by THE PRESIDENT and seconded by Mr. F. W. GOODENOUGH, and declared carried unanimously :—

"That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms during the past session, and records its appreciation of the encouragement and support which the Society has received."

This terminated the formal business before the meeting, and THE PRESIDENT then called upon Mr. A. P. TROTTER to open the discussion on "**Some points in connection with the lighting of Rifle Ranges,**" and a discussion ensued in which the following took part :—Mr. A. BLOK, Mr. SCHAMASCH, Mr. P. J. WALDRAM, Mr. H. BRAZIL, Col. GAITSKELL BURR, Mr. FREAK, Mr. W. J. BASSETT, and Mr. G. HERBERT. The HON. ASSISTANT SECRETARY (Mr. J. S. DOW) also read in abstract contributions to the discussion from THE COMMANDANT of the HYTHE SCHOOL OF MUSKETRY, Mr. FRANK BAILEY, Mr. J. G. CLARK, and Mr. S. G. CORAM.

THE PRESIDENT in closing the proceedings called for a vote of thanks to Mr. TROTTER for opening the discussion and announced that the first meeting of the next Session would take place in November next.

REPORT OF THE COUNCIL FOR THE SESSION.

DECEMBER, 1914—MAY, 1915.

(Presented at the Annual Meeting held at the House of the Royal Society of Arts, on Tuesday, May 18th, at 7.30 p.m.)

THE report of the Council for the period 1914—1915 appears in circumstances very different from those existing at the end of the last session. At that time everything pointed to an active resumption of work in the autumn under most favourable conditions. The international side of the movement had assumed definite shape through the formation of the International Commission on Illumination. The Society in the United States and the newly formed Society in Germany were actively carrying on their work and in France and Belgium the movement was also making steady progress. Active steps were being taken for the extension of the work of the Society throughout the United Kingdom and the official organ of the Society for August contained a special summary, giving the aims and the work so far performed by the Society. It was intended to send out this number with a view to enlarging the membership of the Society and increasing its scope of operations.

Scarcely had this issue appeared when the war was upon us. International co-operation was brought to a standstill, and it became evident that the proposed widespread effort to arouse interest in the movement would have to be postponed.

Nevertheless it was felt to be essential to maintain the continuity of work of the Society as far as possible, and it was hoped that the present exceptional circumstances, while checking the activities of the Society in some directions, would provide opportunities for useful work in others, light being necessary in all times, alike in peace and in war.

MEMBERS ENGAGED IN WAR WORK.

It need hardly be said that the carrying out of the usual programme of the Society presented difficulties. Many of the younger members have joined the forces; others have been engaged in special professional work for the Government. Our President, for example, has been very fully occupied in medical work in connection with the war. Other members have been necessarily immersed in extra labours caused by the withdrawal of so many men from their ordinary occupations, and the dislocation of business conditions generally. A considerable proportion of the members of the Society have been engaged in the important duty of maintaining the supply of gas and electricity, and the exceptional demands of factories engaged in preparing munitions of war on the one hand, and the unusual requirements as regards diminution in public lighting on the other have added to their responsibilities throughout a difficult period. Members interested in acetylene, incandescent oil and similar portable systems of lighting have been very busily engaged in Government work. Many members also have undertaken new responsibilities as special constables or in connection with volunteer corps.

MEMBERSHIP MAINTAINED.

In the circumstances it was also natural that there should have been a certain number of resignations and a considerable increase in membership during the year could scarcely have been anticipated. We are glad to say, however, that the present number of members stands at a figure slightly above that prevailing at the commencement of the war. All things considered the Society may congratulate itself on this result under such unfavourable conditions.

During the session Sir Corbet Woodall and Mr. Thomas Alva Edison have accepted nomination as Honorary

Members of the Society, and in accordance with the arrangement made with the Institutions of Gas and Electrical Engineers last year the President of these two bodies, Mr. Bond, and Sir John Snell were invited to act upon the Council of the Society.

At the commencement of the session the question arose whether the ordinary programme could be carried out; in view of the many important applications of light illustrated by recent events, it was decided to hold regular monthly meetings, but to select, as far as possible, subjects for discussion which would be of special interest at the present time.

MEETINGS OF THE SOCIETY.

Five meetings, not including the Annual General Meeting, have been held. At the opening meeting on 1st December, 1914, there was a general discussion on Illuminating Engineering in War Time. Some of the problems arising through the war were considered and reference was made to the alterations in outdoor lighting that have been made, as a measure of precaution against hostile aircraft. It was pointed out that the methods of concealed window-lighting recommended at previous meetings of the Society, and the avoidance of glaring sources were best adapted to comply with the requirements made by the authorities.

In this discussion it was considered expedient to avoid any detailed comment on or criticism of the alterations in public lighting made since the commencement of the war, the aim of the Society being simply to assist its members and the public in complying loyally with any steps taken by the authorities in the interests of public safety.

The framing and carrying out of general regulations for the lighting of shop-windows and streets in war time, undertaken at short notice, was doubtless a difficult task. Not unnaturally the regulations were interpreted somewhat differently in the various districts, and it was thought the Illuminating Engineering Society, whose members were accustomed to the consideration of such matters, might be of service. Accordingly, a Committee, including some members of the Society who were also members of the Anti-Aircraft Corps, was formed with a view to making some definite recommendations on shop-window lighting, which would enable the requirements of the authorities to be most satisfactorily fulfilled. After several meetings suggestions were prepared and submitted to the authorities by whom they were sympathetically received and considered.

In view of the great changes made in public lighting since the war began, the Council thought that a record of these conditions might with advantage be kept, by means of photographs and measurements of the conditions of illumination prevailing in the streets of London. Permission has been granted to the Hon. Secretary for this to be done, on the understanding that none of the data should be published until the conclusion of the war.

It is hoped that when that time arrives some interesting data will be available.

The Council takes this opportunity of expressing its thanks to the authorities for the facilities granted in this connection. It is probable that some useful lessons may be learned from the exceptional lighting conditions now prevailing, which will not be without influence on the methods of illumination to be adopted in the future.

The second meeting of the Society on January 19th, 1915, was again devoted to a subject of considerable topical interest, namely, the Scientific Development and Practical Applications of Searchlights. The discussion was opened by Mr. P. G. Ledger and special contributions were made by Mrs. Hertha Ayrton, Mr. A. P. Trotter, Prof. A. Blondel and others. In this discussion it was considered essential to avoid any reference to the arrangements made for home defence, and there were many matters which it was considered inexpedient to mention at the present moment. Notwithstanding these limitations, however, the discussion proved a most useful one and the record of the meeting as reproduced in the official organ for February, 1915, was considered an important contribution to the knowledge of the subject, many problems of more than ordinary interest being suggested.

In view of the restrictions on public lighting it was thought that a paper

dealing with some aspect of interior illumination would be appreciated. Accordingly, at the following meeting on February 16th, 1915, a paper was read by Mr. F. W. Thorpe on the "Development of Fixture Design inRelation to Architecture, Illumination and Interior Decoration." The subject is one of considerable interest to members of the architectural profession and should be the means of drawing the attention of architects to the work of the Society.

On March 16th there was a discussion on the "Marking and Rating of Lamps and the best Methods of Specifying their Illuminating Value." A special contribution was presented by Mr. F. W. Willcox and the discussion was opened by Mr. C. A. Wordingham. The subject is a very important one, both to lamp manufacturers and to the general public, and it is hoped that the discussion will pave the way for the solution of what is admittedly a very complicated question. The experience of the past few years has shown the desirability of some more definite and generally accepted method of marking and rating lamps, and it was thought that an open discussion on the impartial platform of the Illuminating Engineering Society, which includes among its members manufacturers of lamps, both gas and electric, as well as engineers engaged in making use of them, would be helpful in paving the way for such an understanding.

The succeeding meeting on April 28th was given up to a discussion on "Visibility—its practical aspects" which was opened by Mr. C. C. Paterson and Mr B. P. Dudding. This discussion was in several respects supplementary to that on Searchlights, and dealt with many points of considerable interest at the present moment.

The subject of discussion at the final meeting of the session on May 18th, "The Lighting of Rifle Ranges," is again one of topical interest. A very large number of these ranges are being constructed at the present time and in view of the important effect of the conditions of illumination on the convenience of marksmen, a specification of the lighting conditions would be a useful guide to those engaged in their construction.

It will be seen that the Council have been able to continue meetings as usual during the Session in spite of the difficulties imposed by the war, and by the selection of suitable subjects interest has has been kept alive. The attendance at meetings has been more than maintained and the standard in the discussions has been uniformly high. The subjects have also been such as to interest new circles in the work of the Society and connections have been established which should be helpful in time to come. The interest aroused in the papers during the present session has shown the necessity for the platform offered by our Society for the discussion of the many lighting problems awaiting solution.

International Congresses, Committees, &c.

In conformity with the practice of most other societies the Annual Dinner was not held this year on account of the war. There is, unfortunately, little to report regarding proceedings of international congresses. The Illuminating Engineering Society in the United States, however, has continued its work as usual, and a number of valuable papers were read at its Eighth Annual Convention at Cleveland. The National Illumination Commission in this country has held several meetings, and proposes to carry on its work, although during the war various matters which would otherwise have been actively taken up have necessarily been postponed.

At the present time, when so many factories are working overtime on Government work, the subject of industrial lighting is being given special prominence, and the Report of the Departmental Committee appointed in 1913 by the Home Secretary to inquire into the matter is being awaited with considerable interest. We understand that the work of the Committee has proceeded steadily since the war commenced, and its Report, when issued, should do much to encourage more scientific methods of illumination.

Additional Support Required.

The position may be summarised by saying that in spite of the unprecedented conditions arising through the war, the Society has been able to maintain its

useful work. The Society has again benefited by the arrangement providing for THE ILLUMINATING ENGINEER to act as the official organ and to undertake the publication of transactions, the cost of which would otherwise be prohibitive. It has been fortunate in not being called upon to pay many customary expenses, such as rent of offices, secretary's salary, &c.

A debt of gratitude is also due to the Hon. Officers of the Society whose labours have been considerably increased owing to the exceptional circumstances of the past session.

It is becoming evident that in order to make any substantial progress the Society must either secure a considerably enlarged membership or consider an increase in its present moderate subscription. The Illuminating Engineering Society in the United States, in spite of its vastly greater membership, has experienced similar difficulties and is now considering a scheme for dividing members into two classes, namely "members" and "associate members," paying respectively subscriptions of two guineas and one guinea per annum.

The Council consider that additional funds are needed to enable the work of the Society to be carried on in a satisfactory manner, and desire to emphasise the importance of securing additional members. It is laid down in Article 23 in the constitution of the Society that "any member may commute or compound for all future payments and become a member for life, by payment of a sum of not less than £10 10s. (ten guineas)." It is hoped that a number of members will take advantage of this method in order to provide additional funds.

PROGAMME FOR THE NEXT SESSION.

The Council is now engaged in considering the programme for the next session. Members who are willing to read papers are invited to notify the Hon. Secretary as soon as possible, and to send in contributions early in the vacation.

The Council takes this opportunity of inviting any further suggestions as to the future work of the Society, or any subjects which might receive special attention during the next session.

WILLIAM H. BENNETT,
President.

F. W. GOODENOUGH,
Chairman of Council.

LEON GASTER,
Hon. Secretary.

APPENDIX.

LIST OF SUGGESTED SUBJECTS ON WHICH PAPERS ARE INVITED.

THIS list is intended to be suggestive, but is not exhaustive, and the choice of subjects for the next session will naturally be conditional on future events.

It need scarcely be said that all papers and discussions will, as hitherto, be conducted in accordance with the restrictions imposed by the authorities for the safety of the country.

1. Special applications of light in connection with the war.
2. Problems in the lighting of camps, barracks, field hospitals, &c.
3. The use of portable illuminants in emergency work in factories, goods yards, and dockyards, for roadmaking, &c.
4. Specific problems in the lighting of factories and workshops. Results accomplished by the use of illumination by high pressure gas, gas-filled electric lamps, &c.
5. Illumination and portable safety lamps for mines, &c.
6. Modern methods of lighting and illuminants employed in ships, lighthouses, buoys, coast-lights, beacons, &c.

7. The measurement of daylight and its application by the architect to designing window-space, and the access of natural light to interiors. The value of photometry in deciding ancient light cases.

8. Simple methods of calculating beforehand the distribution and intensity of illumination in interiors.

9. Instruction in illuminating engineering: Courses of lectures and laboratory work, &c.

10. The benefits of good illumination from the insurance standpoint, and as a means of preventing accidents.

11. New forms of instruments for measuring light and illumination and new apparatus for use in the photometrical laboratory. Methods of testing colour. Methods of testing the steadiness of sources of light.

12. Special problems in fixture design: the compromise between artistic and illuminating principles.

13. Decorative lighting and illuminating engineering from the standpoint of artistic effect and architectural principles. Possible application to the lighting of streets, squares, &c.

14. The production of light of various colours, and the best means of modifying the spectra of artificial illuminants so as to resemble that of daylight.

15. Problems encountered in the lighting of museums, picture galleries, &c.

16. The decorative lighting of parks, avenues, and flower gardens, fêtes, &c.

17. The physiological aspects of illumination, and the effects of artificial light on the eyes.

18. The correct application of light in projection, searchlights, lanterns, cinematographs, &c.

19. The lighting of billiard tables and other indoor games.

20. The artificial illumination of athletic grounds, tennis courts, skating rinks, bowling alleys, &c.

21. Country house lighting by private electrical installations, by acetylene, or by petrol air-gas and incandescent oil vapour.

22. Theatre lighting: Illumination on the stage and its use to produce scenic effects, &c.

POPULAR LECTURES ON ILLUMINATION IN THE UNITED STATES.

AT a meeting of the Council of the Illuminating Engineering Society in the United States on May 13th, Prof. C. E. Clewell reported for the Committee on Popular Lectures. He stated that the manuscripts of the first two lectures had been received. These lectures would deal with Residence Lighting and Store Lighting respectively and would be submitted to the Council for approval very shortly. The Committee has in preparation a series of five lectures dealing with industrial, store, office and residence lighting, and one on the fundamentals of light and illumination. It is intended that copies of these lectures, which will be presented in an attractive and elementary form, will be available for loan to those who wish to give addresses on the subjects, and lantern slides will be prepared to illustrate them.

SOME QUERIES IN CONNECTION WITH THE LIGHTING OF RIFLE RANGES.

THE following series of queries was prepared as an introduction to the discussion on the above subject, and has been circulated among a number of experts and authorities on musketry.

This list of queries is not intended to be exhaustive, but merely to serve as an indication of the scope of the discussion. It will be observed that a number of those who took part in the discussion refer to special aspects of the question which have come within their experience.

The following are some of the suggested points dealt with in the discussion :—

(1) Should the main object of a miniature rifle range be to afford an opportunity for learners to practise the art of holding a rifle, aiming or firing under simplified conditions, without regard to the reproduction of ordinary practical conditions ?

(2) Assuming that artificial lighting is employed, should this be used mainly or solely to illuminate the target with the object (rightly or wrongly) of simplifying the conditions and making them easier ?

(3) Do these artificial conditions of lighting conduce to skill in a specialised and artificial type of shooting ?

(4) Assuming that the light is concentrated solely on the target and that conditions for highest acuity of vision of the target are desired, what is the best degree of illumination ? Does an excessive illumination lead to " irradiation " (*i.e.*, an apparent encroachment of the white surface over the black bull) ; if so, what should be the permissible limit of illumination to avoid this effect ?

(5) Does a dark background for the target (*a*) conduce to acuity of vision ? (*b*) assist in aiming—or does it introduce difficulties ?

(6) Does concentration of light on the target and darkness in other parts of the range, resulting in the enlargement of the pupil of the eye, have an effect on acuity of vision (*a*) of the target ? (*b*) of the sights ?

(7) Is it desirable for miniature ranges to use targets in which the contrast between the bull's-eye and the card is less than that obtained by printing black on white ?

(8) Is it agreed that sources of light used to illuminate the target should be completely screened from view ? Is it better to have the surroundings comparatively dark or to have a more moderate contrast between surroundings at target ? Is there any general understanding as to whether results by artificial light are better or worse than those obtained in daylight ?

(9) Is it desirable to attempt to produce conditions of light similar to those existing out of doors ? If so, what steps should be taken to imitate these conditions ?

(10) What special lighting arrangements, if any, are desirable to facilitate the observation and recording of results and the manipulation of targets from the firing end ?

SOME POINTS IN CONNECTION WITH THE LIGHTING OF RIFLE RANGES.

By A. P. Trotter.

Introduction to Discussion which took place at the Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.C.), at 8.15 p.m., on Tuesday, May 18th, 1915.

In opening the discussion on the lighting of rifle ranges, a word of personal explanation is needed. I have some acquaintance with the science and technology of illumination, and with the elementary physiology of the eye, but I have accepted the invitation to start the proceedings to-night, not because I am an experienced rifle shot, but on the contrary, because I have encountered such difficulties that I can perhaps present them for consideration more vividly than one who is a good marksman, and who only hears of these difficulties from his pupils. I hope by submitting these to experts to obtain help for others.

Before turning to the question of the lighting of rifle ranges, let us consider what rifle shooting consists of. It may be divided into three kinds. The use of service rifle and ammunition on ordinary open air ranges, the use of the Morris tube or miniature rifles on open air ranges, and lastly of miniature rifle ranges illuminated by artificial light, and from which day light is generally excluded.

Dismissing "grouping" practice and rapid firing, the object is to place as many shots as possible as near the middle of the bull's eye as possible. We may dismiss too the various positions of the marksman's body and of his arms, the art of trigger pressing, and deal exclusively with aiming and the considerations of lighting which affect this.

The recruit is shown the foresight and the notched backsight of a rifle, and is told to hold it or to place it on a stand so that the top of the backsight is level,

Fig. 1.

the top of the foresight is exactly in the middle of and in a line with the top of the backsight, and the bull's eye touching or as it were resting on the tip of the foresight. This instruction is elucidated by diagrams showing the right way and several wrong ways of aiming.

Now this is a bad beginning, for the recruit tries, and at once finds that it is impossible to see anything of the kind. If he has normal sight he can see the bull's eye clearly. The foresight is about 39 inches from his eye, and if he directs his attention to it he can see it clearly. The backsight with the notch is about 17½ inches from his eye. If he looks at it with both eyes he may see it clearly, with one eye not so well, but to see all three clearly at the same time is impossible. What is possible is to

Fig. 2.—Appearance of sights against a white target 6 inches wide on a dark background.

put the rifle in such a position that when attention is directed, or in other words

when the eye is focussed on each of the three objects in succession, they appear to be in alignment. Finally, attention is always directed to, and the eye is focussed on to the target. If the learner is long sighted, short sighted or astigmatic and cannot see the target clearly, he can use glasses which will remove that disability and he will start fair with normal sighted men.

A middle aged or elderly man has greater difficulties in sighting, and these become much more serious in a weak light. A year ago not much attention would have been paid to this. Musketry instructors had to deal with young men, and rifle shooting for middle-aged men was only an amusement. To-day there are thousands of volunteers of ages between 40 and 70 or older who having struggled for permission to bear arms, wish to know how to use them, when they get them.

The crystalline lens of the eye is a stiff jelly surrounded by a muscle called the ciliary muscle. When this muscle contracts the lens becomes bulged and increases in optical power. In youth this accommodation as it is called is considerable, but with advancing age it diminishes, because the lens becomes more rigid. Sometimes the lens puckers when it bulges, possibly because it is stiffer in some directions than in others, for its structure is not homogeneous. This causes temporary astigmatism, but it may be removed completely by the use of ordinary reading glasses which make no call upon the focussing property of the eye. Judging from the experience of my friends, my own eyes are fairly representative of this class. My vision is normal, and so far as I am aware, perfectly free from astigmatism for distant objects. I can see shot holes about ·12-inch diameter on a target by daylight without a glass, at 25 yards, subtending an angle of about 27 seconds. I did not begin to use glasses for reading until I was 54, that is, four years ago. Many years ago, on the very few occasions that I used a rifle, I found that I was a tolerable shot, probably owing to "duffer's luck," a well recognised condition which does not seem to have been explained by physiologists or psychologists. In February last I went to a gas-lighted miniature rifle range, and was disgusted to find that while the target was clear, the backsight was a mere blur or cloud and that while the rifle was tilted upwards I could see the foresight, but when I brought it down into the fuzzy foresight I saw multiple and uncertain images. Holding the rifle steady, and moving my eye from side to side horizontally, these images moved in a capricious way. I spent some time in practice shooting, trying to find some definitely reproducible arrangement of the images of the foresight. The only thing to do in such circumstances is to discover something definitely reproducible and stick to it. I have found no account of the phenomenon in any official handbook on musketry, no instructor has given me any help. A writer on "How to become a marksman" finishes a short article as follows: "Men over 40 years of age are lucky if they can see the backsight clearly as well as the bull's eye. The usual feeling is that there are two or three overlapping each other, producing a smudgy appearance. I suggest the use of glasses which will clear the bull's eye, and you must deal with the backsight as the batsman did who could see several balls at once—go for the middle one." Now this gives no help. In the first place I find and others find that the foresight and not the backsight has a multiple appearance, the backsight it is true looks smudgy. But glasses to clear the bull's eye are not needed, and any one who can see the target clearly without glasses will assuredly see it less clearly with glasses.

I found at last, that by taking a very fine sight, that is, allowing only the extreme tip of the foresight to appear, the third image was suppressed but the foresight was double. This position would shoot low, and it was necessary to aim high or to raise the sight. The direction was definite, but the elevation was difficult. The smallest motion of the head sideways caused complicated images to appear. An experiment made by Mr. S. D. Chalmers showed that this was not due to a defect in my eye, but it can be reproduced by projecting on a screen the images of a slightly out of focussed pin and a much out of focussed notch. The scientific consideration of

these would be beyond the scope of the present discussion unless someone will tell us how they may be definitely utilised in aiming.

It seemed hard to persevere with these experiments when a simple device has been provided which does away at once with all the trouble. This is the aperture or orthoptic sight, nothing more than a small diaphragm or peep hole fastened to the rifle. But the use of such a sight is forbidden in the passing tests of the Corps to which I have the honour to belong. "Ours not to reason why," but one may guess that the aperture sight as usually constructed is more liable to damage than the ordinary open sight. We need not grumble, the test is an easy one, and would perhaps be too easy with an orthoptic sight. Several men who were shooting no better than I, seemed to experience the same troubles, and some despaired of passing the first test.

A few weeks ago I had the opportunity of shooting with service ammunition on an open air range at 200 yards. On taking aim I was surprised to see a single foresight and a tolerably distinct backsight. It stood out against the butts far more distinctly than in a dark range. I threw over my carefully devised plans for aiming, and applied the ordinary official rule with satisfactory results.

I had tried without success to investigate the multiple images by experimenting with improvised sights in an ordinary room, but I could not reproduce them. After a few minutes experience with a rifle in broad daylight it occurred to me that the difficulties arose in the dark and that the pupil of my eye would then be enlarged. On repeating my experiments in a dark room I found it easy to reproduce these phenomena. Mr. Chalmers points out that in a darkened range the diameter of the pupil of the eye is considerably greater than the width of the notch of the backsight.

My next step was to search for an open air miniature rifle range, and having discovered one, I was not surprised to find that aiming according to the usual rule was applicable. I used the two inch bull's eye, because I have to pass my test on it. I prefer the one inch. On my third attempt, 8 shots out of 10 were on the black, the two others being on the next ring (counting 8). This was encouraging.

But the test by gas light had to be passed,* and practice by day light was only for personal gratification and for anticipation of the real thing. I tried the weakest pair of spectacles that I had, of a power of $\frac{1}{2}$ dioptre. This made the foresight clear, but the bull's eye was quite out of focus. It was possible to aim at the middle of the smudge, but the results were not good enough. After some trouble I obtained a pair of $\frac{1}{4}$ dioptre. In order to raise the lens to the proper position I wear them upside down. The bull's eye is tolerably clear but the foresight becomes misty when it is lowered into the V of the backsight, and the two little duplicate images begin to appear. The result is perhaps a good compromise.

The difficulties which I have described at perhaps too great length arise from two physiological causes: the diminished accommodation owing to advancing age, and diminished definition owing to the enlarged pupil, this being due to the feeble illumination of the miniature range. Excellent shooting is being done every day in these ranges by young men and women and no doubt also by middle aged men who are naturally good shots or experienced in that kind of shooting. It is an amusing pastime, almost as good for a steady hand and eye as billiards, but it affords practice only in some of the requirements of practical rifle shooting.

Passing now to the questions which have been prepared for our consideration, I think that we may agree that even a dark miniature rifle range affords an opportunity for learners to practise the art of holding a rifle, aiming, and trigger pressing, and these are undoubtedly the first elements of rifle shooting. If they acquire competence here, they will doubtless do well with service ammunition in the open. But the point which I wish to urge is that

* Since this was written, an opportunity has been given for passing the tests on an outdoor range. Many members of my Corps, including myself, who had shot badly in an artificially-lighted range of the usual type, had no difficulty in passing the test.

if they do not succeed in the dark, they should not be discouraged but should try a daylight range.

The second question assumes that artificial light is used, and asks whether is should be used mainly or solely to illuminate the target. Opinions probably differ here, for nothing but a definite demand could have led to the careful exclusion of light from most of the miniature ranges. The probable reason for this is that other lights than the carefully concealed ones which light the targets would cause glare unless very evenly diffused. It must be admitted that these conditions conduce to skill in a specialised and artificial kind of shooting.

board illuminated by day light is so grey that the back sight can be seen against it. In one open air range, targets are sometimes fastened against clean white boards. This is a great advantage for elevation.

The sixth question asks whether concentration of light on the target and darkness in other parts of the range resulting in the enlargement of the pupil of the eye, has an effect on acuity of vision (*a*) of the target, (*b*) of the sights. Provided that the target is not too brightly illuminated, surrounding darkness probably helps as far as the target is concerned. Young men probably find that the darkness does not interfere much with the sights because in spite

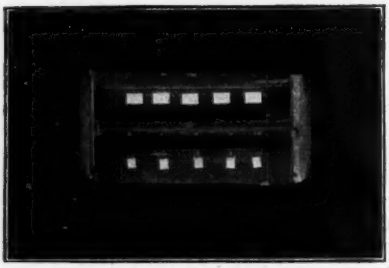


FIG. 3.—Typical indoor Miniature Range.

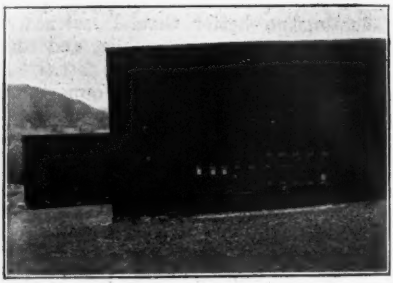


FIG. 4.—An outdoor Miniature Rifle Range.

Showing characteristic difference in the conditions of contrast in the ordinary indoor range (firing point in complete darkness) and in the case of a similar range out of doors.

I will leave the fourth question to Mr. Dow or to others who have made measurements of the illumination in several ranges. A target may certainly be too brightly illuminated, but the disturbing effect seems to be due to glare rather than to the apparent reduction of the diameter of the bull's eye by irradiation.

There seems to be a demand for dark backgrounds, and I can only express my own view on this, but I know that it is held by others. I find that the targets used in the miniature ranges are so small that they do not afford a background for the top or shoulder of the back-sight. In the open air, even a black

of an enlarged pupil they have the power of accommodation or focussing: but older men have much more difficulty with the sights in a dark range than in a light one. I can offer no opinion on the question of using other contrast than white and black for the targets. The target is admittedly a conventional object. We have others in our thoughts.

The reply to the first part of the eighth question undoubtedly is that sources of light should be screened from view. A light over the heads of the marksmen probably leads to low shooting. The last part of the question as to whether the results by artificial light are better

or worse than those obtained in daylight should be answered by those who have much wider experience than mine. The Official Military Book on Musketry Regulations, Part II., states (p. 46) "Indoor ranges, if suitable lighting arrangements are made, can be used for firing at night almost as satisfactorily as by day." "As much light as possible, preferably from above, should be admitted at the target end."

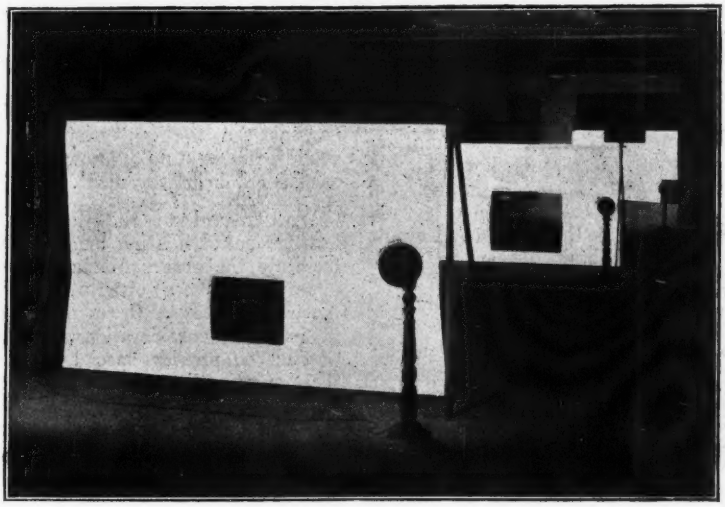


FIG. 5.—Special arrangement of a series of illuminated white screens having apertures through which the target is viewed.

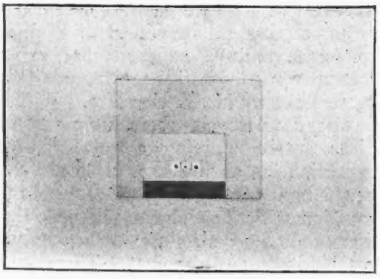


FIG. 6.—View looking through the aperture at target as shown in Fig. 5.

My reply to the ninth question is that it seems desirable to attempt to produce conditions of light similar to those existing out of doors so far as diffusion of light is concerned, and it should be quite practicable.

Mr. H. Brazil has kindly carried out a suggestion of mine at a private range belonging to the electric lighting company of which he is engineer. Fig. 5 shows a side view and Fig. 6 a view taken from the firing point. The targets are placed against a white paper background 5 ft. high and 8 ft. wide. Two screens of white paper also 5 ft. by 8 ft. are arranged, one at 10 ft. the other at 40 ft. from the firing point and apertures are cut in them. The aperture in the middle screen allows nearly the whole of the background to be seen, and the aperture in the front screen allows nearly the whole of the middle screen to be seen. The screens should have an illumination of not less than 5 foot-candles, and the targets and background might be more strongly illuminated. The object is two-fold, to give a background against which the shoulder or flat edge of the backsight can be seen, and to give a large flux of light which will cause the pupil of the eye to contract. Where several men shoot together the apertures would be wide.

Continued Discussion on Lighting of Rifle Ranges.

Mr. A. BLOK said he would confine himself chiefly to the illuminating engineering side of the problem and leave others to deal with the military and physiological aspects. He agreed most emphatically that the object of lighting miniature ranges should be to make the conditions as easy as possible for the users. The work carried out on such ranges was by no means final, but it was an important preliminary to work on outdoor ranges and under service conditions. He was also of the opinion that in lighting ranges artificially the effect to be sought should be to direct light on to the target and not pay too much attention to the surroundings. Referring to the question as to whether the targets should have a bright or a black surround, his opinion, formed after the examination of several ranges, was that the most comfortable conditions were obtained when the targets were mounted on a background of intermediate brightness. He, personally, had experienced the greatest visual comfort on a range having a brown card mounting for the targets, the target brightness being about double that of the surround. Thus, with a surface brightness of 10 foot-candles on the target, good results were obtained if the surround had a brightness of about 5 foot-candles. He thought that the usual white target with black bullseye was most suitable for beginners because, although there seemed no doubt that a man's shooting at a certain stage of proficiency could be very much improved by the use of targets having a contrast less than that of black and white, these targets of low contrast gave the beginner poor scores and therefore discouraged him. It must not be forgotten that the psychological side of marksmanship is an important factor.

He inclined to the belief that the question of whether the light used to illuminate the target should be completely screened from view or not had not yet been properly investigated. It might generally be taken as bad to have exposed lights on the range, but a great deal might be effected by providing a well-diffused and moderate general illumination around the firing-point. He thought that the practice of keeping the firing-point in darkness was bad, for the reason that it was dangerous and uncomfortable. Furthermore, it made the instructors' work more difficult and probably conduced to optical fatigue by compelling the marksman to look from the brightly-lighted target to the gloom of his immediate surroundings when loading or giving attention to any other matters on the firing-point.

He would be very glad if Mr. Trotter would say whether he thought that a material improvement was effected by the use of the white screens in the case of the Charing Cross range. Mr. Trotter had said that the result was good, but it would be interesting to know if there was a considerable improvement.

With regard to the desirability of having special lighting arrangements to facilitate the observation and recording of results, that was often a very difficult matter to achieve. Generally, by reason of practical considerations, it was not possible to provide special illumination for "spotting" or counting the scores, and the ordinary condition seemed to be that the illumination on a range must do for all purposes without the option of changing it for special purposes. The matter seemed important, however, because in the opinion of some range officers spotting work was far more fatiguing to the eye than the actual aiming itself during a prolonged spell of work. There was, in this connection, the possibility of an interesting application of the Galilean telescope, and he believed that experimental work upon this matter was being carried out by Mr. F. Cheshire. With an ordinary telescope, there were ten air-glass surfaces giving a total loss by reflection, on an average, of 33 per cent. of the light coming from the target to the eye, but with the Galilean telescope there were only four air-glass surfaces, giving a total loss of 15 per cent. Therefore, it seemed that it would be worth while to develop a simple form of Galilean telescope for spotting purposes. The drawback with the Galilean telescope was that it had a very small field and, accordingly, it would only cover one target or a portion of one target in place of the large surface

which could be covered with an ordinary terrestrial telescope.

As to the degree of illumination necessary upon a target, he had carried out experiments in conjunction with Mr. A. Schamasch on S.M.R.C. bull targets and Bisley 200 yards and 500 yards figure targets.* Arrangements were made whereby the target illumination was raised from 0·8 foot-candles to about 500 foot-candles, the high illuminations being obtained by means of a 2,000 c.p. gas-filled lamp kindly lent by Mr. F. W. Wilcox. With the bull target and an open sight, the most comfortable illumination was found to be about 12 foot-candles. Beyond that, a reddish colour fringe began to assert itself along the back sight and at 50 foot-candles this fringe had so far increased as to make the shooting very difficult. Multiple images or "fuzziness" also appeared, giving a dark halo around the fore and back sights, and when the illumination had increased to values between 60 and 100 foot-candles the bull became visible *through* the fore sight, which was a rather unexpected result. At 200 foot-candles, the glare from the white card became very bad —the target was, in effect, a powerful secondary source of light—and aiming became very difficult.

When an aperture sight was used on the bull target a similar sequence of events was found, but the illumination for most comfortable aiming was slightly higher than with the open sight, as would have been expected. There seemed little doubt that the aperture sight gave a more comfortable result provided that the illumination was sufficiently high to enable the target to be seen through the opening. It was found that beyond about 50 foot-candles troubles due to diffraction effects or irradiation (it was sometimes difficult to separate the two) increased when the aperture was made smaller.

With the figure targets, substantially the same troubles were found as with the bull pattern, but the most comfortable aiming was done at about 15 foot-candles with open sights and from 20 to 30 foot-candles with aperture sights. Here, again, it was found that from 100 foot-candles upwards it was impossible to aim comfortably with open sights, notwithstanding that this illumination is far less than that obtained on daylight ranges. These experiments seemed to lead to the following conclusions :—(i.) It is possible to over-light a range; (ii.) For a black and white bull target, 12 to 15 foot-candles is a comfortable illumination, whilst for figure targets of the nature used, the illumination may be from 20 to 30 foot-candles; and (iii.) The aperture sight gives easier aiming than the open sight on a range lighted artificially similar to the one used for these tests. It must be borne in mind, of course, that the above figures apply to the eye of one observer, and although the eyesight of the observer might be accurately described as normal it was possible that other observers would find that their requirements were different.

SOME EXAMPLES OF THE LIGHTING OF MINIATURE RIFLE RANGES.

Mr. Blok then showed a number of lantern slides of ranges on which he had experimented, together with the curves showing their distribution of illumination. The data for these and some other ranges are here appended, and in connection with them it may be explained that the ranges were tested exactly as they stood, without any special cleaning or adjustment of the lighting equipment. In some cases, shooting was actually interrupted for the purpose of making the photometric tests as the object throughout was to obtain values representative of practical conditions.

Ranges of the National Reserve City of London Battn: Rifle Club, Blackfriars.

The National Reserve Rifle Club has two ranges extending under the Thames Embankment, and each containing two

* The S.M.R.C. target has a black bull on a nominally white card, and the figure targets have a brown mark, representing conventionally the front elevation of a prone man. The mark lies partly on a green field and partly against a grey sky, the junction of the field and sky being a horizontal line across the target. The targets used in the tests had surface brightnesses in the following ratios: brown: green: grey for the 200-yards target were as 1 : 1·8 : 3·7 and for the 500-yards target as 1 : 2·2 : 3·4.

superposed rows of targets separated from each other by a horizontal partition, as shown in Fig. 1. On both ranges the targets are lighted by a row of electric lamps near the ceiling and another just below the floor level, and the partition

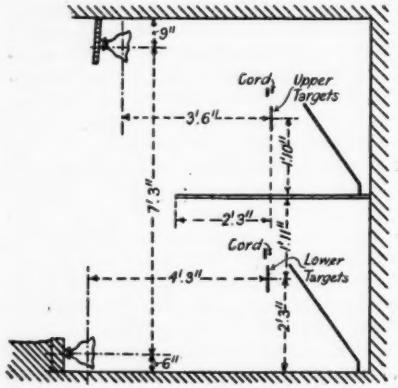


FIG. 1.—National Reserve Rifle Club Ranges.
Disposition of targets and lamps on right-hand range.

extends outwards sufficiently to prevent any light from the ceiling lamps from reaching the lower row of targets or light from the floor lamps from reaching the upper targets. There are five lamps in each row, varying from 40 to 60 watts, spaced two feet apart, and fitted in the case of the right-hand range with prismatic glass reflectors. At the time when the tests were made, these reflectors were all very dirty and portions of some had been broken away, no doubt by ricochet bullets. The middle lamp of the lower row was entirely without a reflector.

The walls of the range tunnel and the background beyond the targets are dark, but whitewash has been put on the underside of the horizontal partition and on the walls along a strip extending about ten feet from the targets towards the firing-point.

Fig. 1 shows the arrangements in the right-hand range, and those in the left-hand range are substantially the same, excepting that the lamps are fitted with enamelled steel reflectors of the so-called "45 degrees parabolic" type with frosted aluminium interior surfaces. The lamp spacing and curves of illumination along the bullseye lines for the four sets of targets are shown in Fig. 2. It will be seen that in both ranges the upper row of targets is better lighted than the lower one, and that the metal reflectors give a marked advantage in the matter of uniformity of illumination. The curves A and B could, without doubt, be raised considerably by cleaning the glass reflectors, and the writer was indeed told by the range warden that the lighting of the right-hand range is noticeably improved whenever the reflectors are washed. This is a practical point worth attention: in the present case, the shallow pit in front of

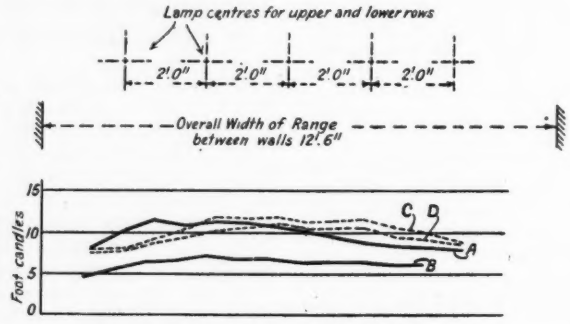


FIG. 2.—National Reserve Rifle Club Ranges.
Curve A = Illumination on upper targets of right-hand range.
" B = " " lower " " " "
" C = " " upper " left-hand "
" D = " " lower " " "

the targets is topped with a thick layer of dust which lodges freely on the lamps and reflectors under the action of the lead splashes, and, for this reason, prismatic glassware of the pattern which has no metal protection over the prisms appears to be inapplicable on this range.

The curves show a declining illumination towards both ends of each row of targets, and this effect, which will also be noticed in some of the curves which follow, of which has been blackened. Before this blackening was employed, trouble was experienced owing to sunlight coming through the glass and forming a luminous haze in the smoke which accumulates in the range, but this difficulty disappeared when the glass was obscured. The target chamber is lighted entirely by electric lamps placed as shown in Figs. 4 and 5, in which L^1 indicates the position of three 25 candle-power lamps with 9 in. opal

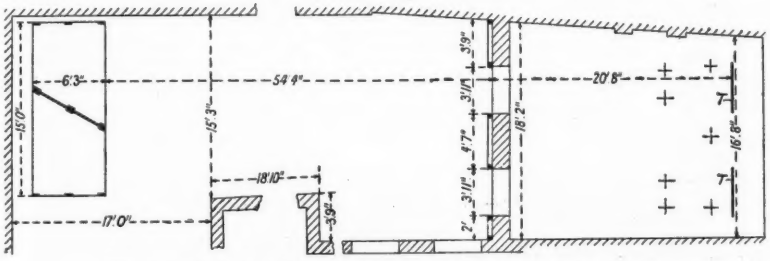


FIG. 3.—Range at H.M. Patent Office. Plan view of range lay-out.
T = Targets. + = Lamp centres.
The firing-platforms are indicated by the obliquely-divided rectangle at the left-hand of the diagram.

is common on ranges lighted by lamps placed in straight rows. With such a distribution of lamps, uniform illumination across the targets can only be obtained by the use of special reflectors or by increasing the candle-power of the end lamps.

Range at H.M. Patent Office.

The structural nature of the basement in which this range is situated makes it a somewhat interesting example. As shown in the plan view, Fig. 3, the targets, T, are placed at the end of a long room which is divided transversely by a brick partition fifty-four feet away from the firing platforms. This partition has two openings, each approximately four feet wide by six feet high, through which the targets are seen, and the front of the partition, *i.e.*, the side facing the firing-point, is faced with blackened wood. The targets are situated in a chamber, about twenty feet long and seventeen feet wide, of which the walls are finished with a pale yellow distemper. Between the firing-point and the partition there are two glazed roof lanterns, the glass conical reflectors, and L^2 indicates four lamps mounted on an inclined batten and provided with frosted aluminium and steel reflectors of an intensive type. The two outermost lamps, L^2, are of 65 candle-power

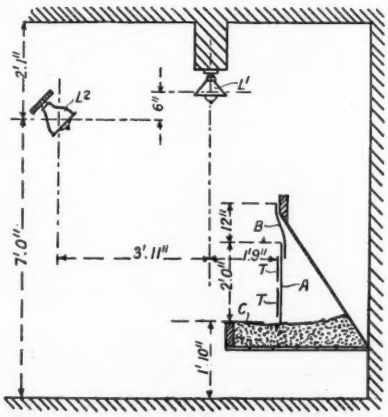


FIG. 4.—Range at H.M. Patent Office, London.
A=Brown millboard. B=Green baize.
C=White card. T=Targets.
L^1=25 c.p. lamp. L^2=65 and 100 c.p. lamps.

each, and the two inner ones are of 100 candle-power. The lamps, L^1, contribute only a small amount to the target illumination, and they are used merely because they happened to be already installed as part of the basement lighting before the targets, T, are clipped on to renewable sheets of brown millboard, A, above which is a strip, B, of dark green baize about a foot deep. This strip was provided for the absorption of lead splashes, but the fortuitous choice of a green material for

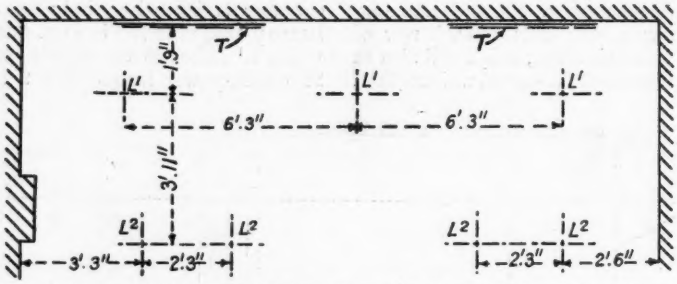


FIG. 5.—Range at H.M. Patent Office. Plan view of lamp and target positions.
T=Targets. L^1=25 c.p. lamps. L^2=65 and 100 c.p. lamps.

range was put in. Sheets of white card have been hung on the conical reflectors to assist in directing the light on to the targets, and no portion of any lamp or reflector can be seen from the firing-point. Fig. 6 is a photograph of the targets and lamp arrangement taken inside the target chamber, and the appearance of the targets as seen from near the firing-point is shown in Fig. 7. (These photographs were taken by Mr. Dow, entirely by the artificial light provided for the range.)

The details of the target mounting are indicated in Fig. 4, and experience has shown that this mounting gives very comfortable aiming conditions. The this purpose has led to an interesting transition of surface brightness from the targets to the black woodwork which forms the end of the range and is visible above the green baize. (See Fig. 7.) The ratio of surface brightness for this mounting is as follows:—green baize : brown millboard : white target = 1 : 17 : 40.

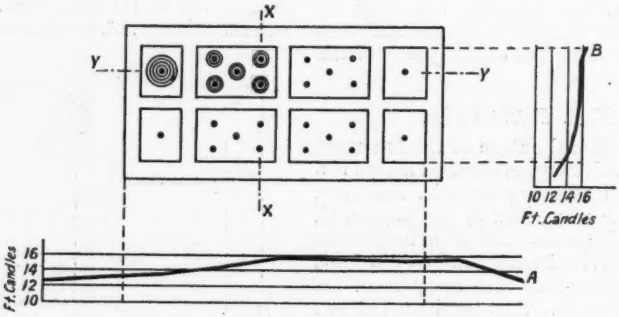
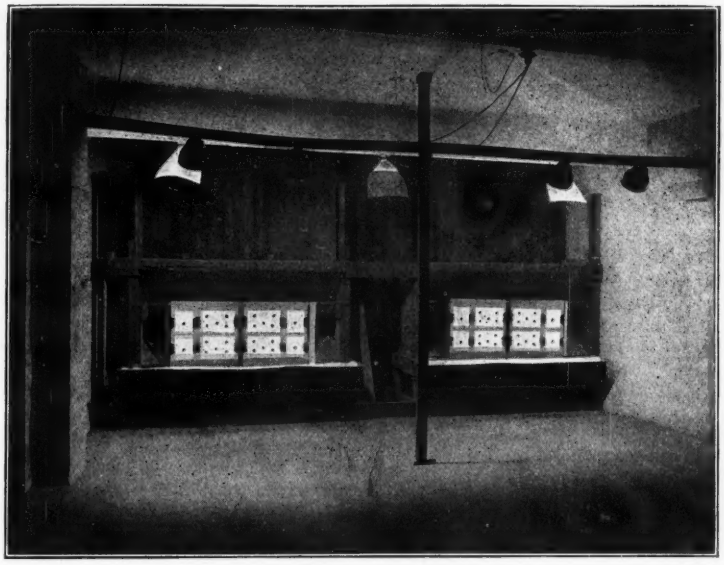


FIG. 8.—Range at H.M. Patent Office.
Curve A=Illumination along line YY. Curve B=Illumination along line XX.

To assist the illumination on the lower row of targets, a strip of white card, C (Fig. 4), is laid horizontally on the shingle box, as plainly seen in the photograph (Fig. 6).

The curve A, Fig. 8, shows the illumination along a horizontal line, YY, through the left-hand set of targets, and the curve



Lumina Bureau Photo.

FIG. 6.—Range at H.M. Patent Office.
View of lamps and targets at close quarters.

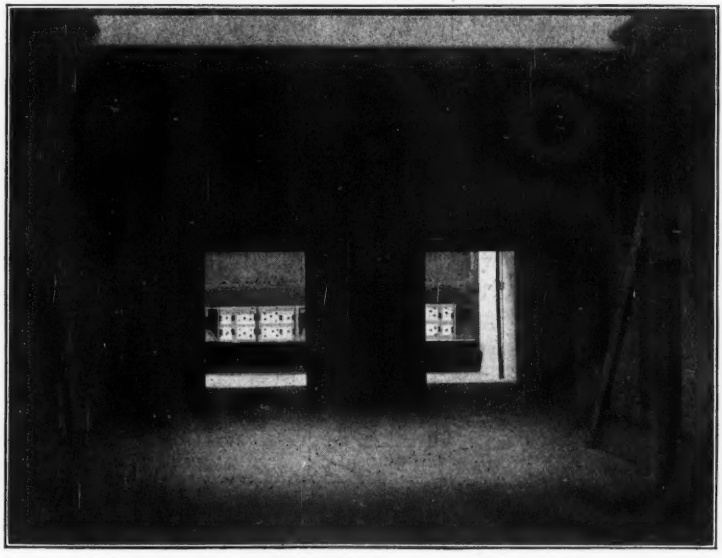


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FIG. 7.—Range at H.M. Patent Office.
View of targets from left-hand firing-point.

B shows the illumination along the vertical line XX. The target illumination is seen to be very uniform, having maximum and minimum values of 15·6 and 12·8 ft.-

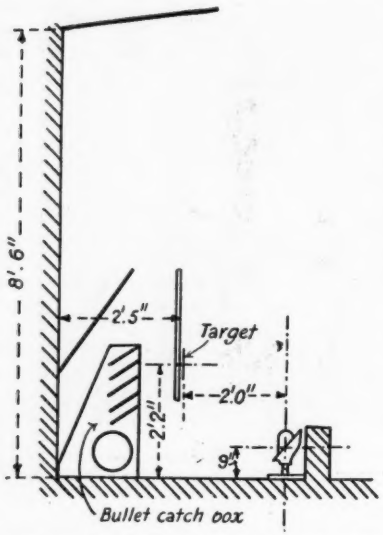


FIG. 9.—Range of the Central Markets Rifle Club, Smithfield.
Disposition of lamps and targets.

candles on the line YY, and 16·1 and 13·5 ft.-candles on the line XX, and there seems little doubt that the uniformity is attributable in great part to the fact that the targets and lamps are placed in an almost completely enclosed chamber having light walls and ceiling.

Range of the Central Markets Rifle Club, Smithfield.

This range, which is situated on a roof, is adapted for daylight and night shooting. The firing-point is under cover with bare lamps, well behind the mats, for general illumination, and the targets are lighted by a row of "footlights," as shown in Fig. 9. The row of footlights comprises eight 55-watt lamps mounted under somewhat thick glass bells in cast-iron fittings with inclined elliptic openings. These fittings have an inner surface of poor reflecting quality, and at the time of testing they appeared to function more as a mechanical protection for the glassware than as reflectors.

The space between the firing-point and the targets is bounded by dark wooden walls and has no roof, excepting a series of spaced transverse timbers so distanced as to prevent the escape of stray shots. The targets are mounted against a dark background on four open wooden frames, each carrying targets for two marksmen, as shown in Fig. 10, the frames being coupled together in pairs and connected to overhead winding-cords operated from the front of the firing platform.

The illumination on the two central frames (see Fig. 10) varies from 11 to 12·2 ft.-candles and is fairly uniform, but on the outermost frames it is seen that the illumination falls to nearly two-thirds of the central value.

Range at the General Post Office, St. Martin's-le-Grand.

Like the Smithfield range described above, this is an open roof range bounded

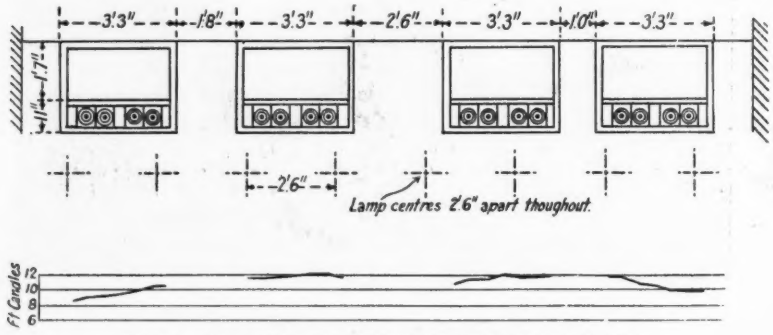


FIG. 10.—Range of the Central Markets Rifle Club, Smithfield.
Curves of target illumination.

by timber walls and having an overhead construction of widely-spaced timber baulks between the covered firing-point and the targets. The targets are mounted in two groups of four behind narrow frames of black wood which protect the target-cords, as shown in Figs. 11 and 12.

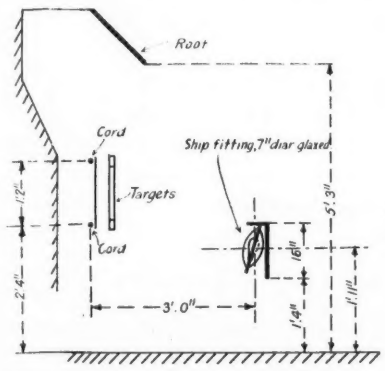


FIG. 11.—25 yards range at the General Post Office, St. Martin's-le-Grand.
Disposition of targets and lamps.

Opposite each group of targets is a row of seven 20-watt lamps mounted in inclined glazed circular ship fittings with concave white enamelled reflectors behind the lamps. The fittings are protected on the firing side by a vertical black board sixteen inches high spaced well above the ground, as indicated in Fig. 11.

The illumination curve, Fig. 12, shows a characteristic heaping-up towards the centre of each group of lamps and a marked falling off of the illumination towards the left-hand end of the row. This falling-off is partly due to the lamps and fittings on the right-hand side being in better condition than those on the left, but a secondary and no less important cause of the difference is apparently connected with the structure of the range itself. As indicated in Fig. 13, on the right-hand side the wooden palisading which forms the walls of the range is carried on to meet the back wall behind the targets, whereas on the left-hand side there is an opening in the palisading adjoining the targets. This opening leads into another range which is dark at night time, so that the opening forms a non-reflecting surface. The palisading of the right-hand wall, however, although dark yellow to brown in tint, undoubtedly contributes to the illumination of the right-hand targets by reflection.

An Army Range in Surrey.

This range, which is used for daylight and night firing, is, in effect, a long rectangular tube of brickwork and concrete 12 feet wide and 8 feet high with two glazed roof lanterns at the ends, over

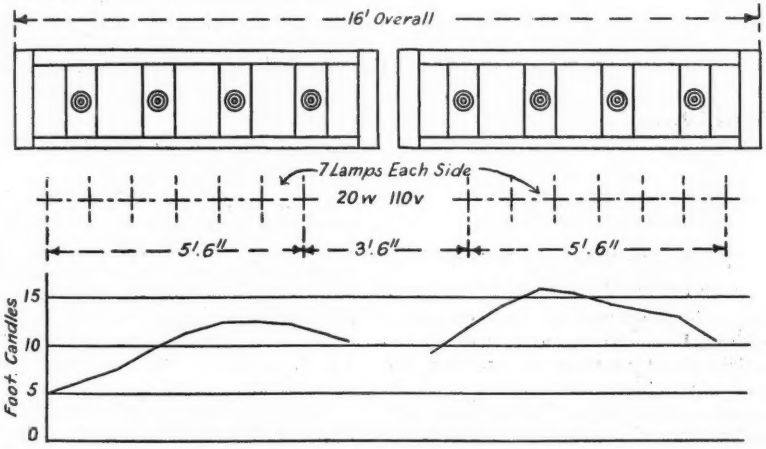


FIG. 12.—Range at the General Post Office.
Curves of target illumination.

the firing platform and the targets respectively. The walls and ceiling are whitewashed along their whole length and the targets are backed by a stack of tarred road blocks.

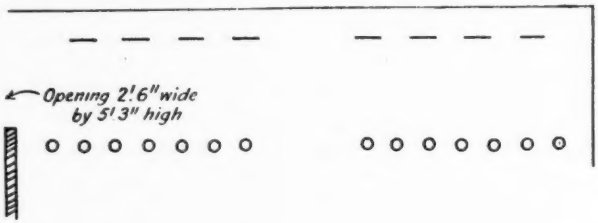


FIG. 13.—Range at the General Post Office.
Sketch plan of lamp and target disposition.

For night shooting, a transverse batten with four electric lamps is used, as shown in Figs. 14 and 15. The lamps are contained in downward-pointing, trumpet-shaped, cast iron reflectors, originally having a white enamelled inner surface but now very much discoloured. The

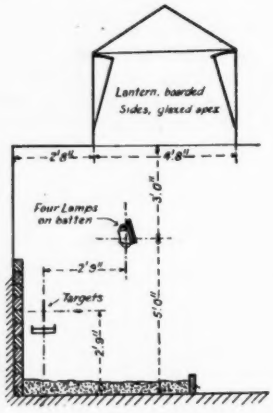


FIG. 14.—An Army range in Surrey.
Disposition of targets and lamps.

batten is supported at each end in a grooved block on the wall, and it was noticed that by rocking the batten in the grooves the target illumination could be varied considerably. The position normally assumed by the batten throws too much light downwards and thus does not make quite the best use of the lamps, but the test was made without altering the setting of the batten from its usual service position. In the extreme left-hand holder there was a 40-watt lamp, and in the three others 60-watt lamps. This asymmetry of the lamps accounts for the depression of the illumination curve towards the left-hand targets, Fig. 16. The range is adapted to take three targets abreast, equally spaced between the lamp centres, but when the test was made four targets were being used, approximately opposite the lamp centres as shown. By interchanging the first and third lamps, counting from the left-hand end, it is evident that the illumination on the targets could be rendered considerably more uniform. No opportunity for trying this was available, however, at the time when the range was being tested.

The overhead lamps, A, were not in use, and the firing-platform was lighted entirely by the pendant, B. There was no sign of glint on the sights and the general illumination on the platform appeared to be just adequate.

Ratio of Maximum to Minimum Illumination on Targets.

In the foregoing description, it will be noted that the ratio of maximum to minimum target illumination has widely varying values, and the question naturally arises as to what limiting value should be allowed for this ratio. In Figs. 8, 10, 12, and 16, the values are approximately 1·2 : 1, 1·32 : 1, 2·66 : 1, and 1·44 : 1 respectively.

Inquiry sometimes shows that there are favourite places on the mats of a given range and the favourite places may be those commanding the best lighted

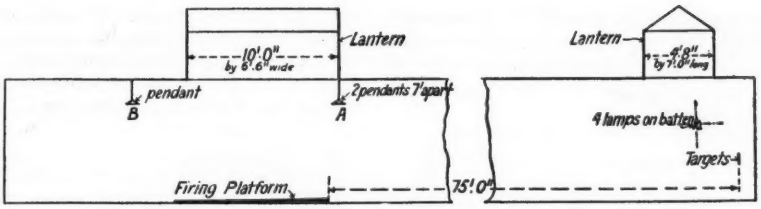


FIG. 15.—An Army range in Surrey. Longitudinal section of range.

targets, or at any rate those which are not allotted to the worst lighted targets. Among the examples shown above, however, the writer could not find definite

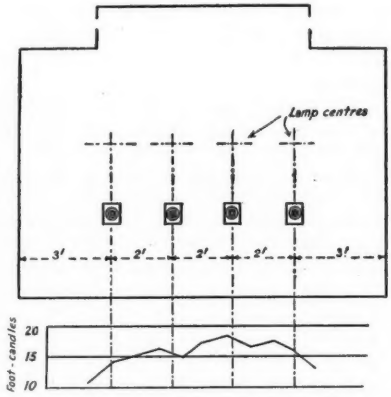


FIG. 16.—An Army range in Surrey.
Transverse section of range and curve of target illumination.

evidence that any of the targets were generally considered by the users of the ranges to be so badly lighted as to be "unshootable." The visual impression given by these ranges certainly did not suggest the large variations of lighting which the photometer subsequently revealed and the general conclusion was arrived at that none of these ranges could be regarded as having intolerable differences in the illumination of its targets. Accordingly it would appear that good aiming is not prejudiced anywhere on a range if the ratio of maximum to minimum illumination on the several targets is not much greater than 2·5 : 1.

An example is shown in Figs. 17 and 18 in which the ratio is 3·5 : 1, and it was evident at the first glance that the end and centre targets on this range were of little use. The range is used by a voluntary training corps and is lighted by two 3-mantle inverted incandescent gas lamps placed behind iron screens, as shown in Fig. 18. The screens were originally whitened behind the lamps, but at the time of testing they were soiled and of small reflecting value, in addition to which one mantle in each lamp was not glowing owing to faulty adjustment of the lamp. A great deal of the light was thrown vertically

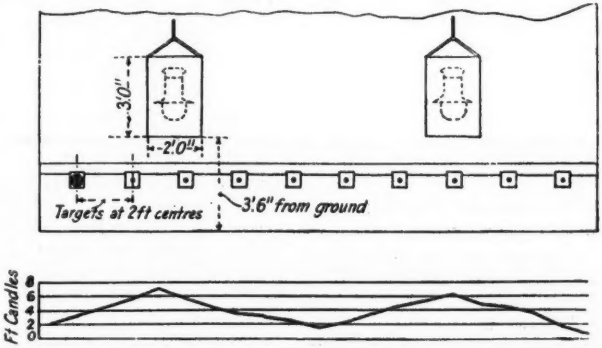


FIG. 17.—A range having a high ratio of maximum to minimum target illumination.

downwards on the ground in front of the targets, and there is no doubt that if the six mantles were redistributed along the

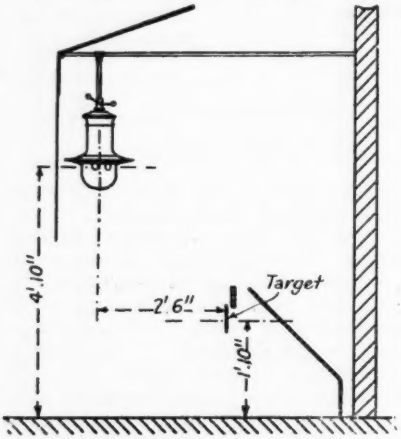


FIG. 18.—Disposition of lamps and targets in range shown in Fig. 17.

range and provided with reflectors of a proper characteristic the twin peaks could be removed from the illumination curve and the illumination along the whole row of targets could be much increased.

Adjustability of Illumination on Targets.

In the majority of ranges, the illumination on the targets is of fixed value, but where targets of different natures are employed—say white targets as an alternative to figure targets or green targets for rapid fire—it is desirable to make provision for altering the illumination at will. This may be done by altering the position of the lamps or by providing extra lamps which are only employed when coloured targets are in use.

A simple arrangement for enabling the lamps to be moved is shown in Fig. 19. The device is used on the range of a well-known regiment having its headquarters in London. The arrangement is shown in section on the left-hand side of the figure and in front elevation in the upper part of the right-hand side. The targets are hung from a cord in front of a vertical board of pale green tint and another board having the same colour and a black upper margin is placed in front of and above the targets. Electric lamps are spring-mounted on the front of a series of spaced wooden box-like structures, five of which are joined together by a vertical strip of wood, as shown in plan at the lower part of the right-hand side of the figure. The boxes contain diagonal steel plates for deflecting stray bullets downwards. Behind each lamp is a concave glass mirror loosely held by a clip in a socket on the front of the box. Connection to the electric supply is made through a plug and flexible cord, and the whole assemblage of boxes, lamps, and reflectors may be placed at any desired distance from the targets. In addition, the illumination on the individual targets may be controlled by tilting the reflectors with regard to the lamps.

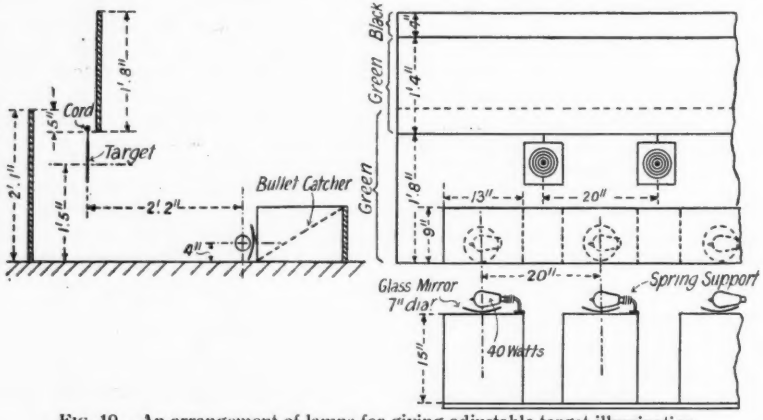


FIG. 19.—An arrangement of lamps for giving adjustable target illumination.

Mr. A. SCHAMASCH said the main object of training on a miniature range was to train the nerves and muscles so that they were subjected to the eye. This, and the correct method of aligning the sight on the mark, were the two important factors in musketry. He believed in eliminating troubles as much as possible from the start; consequently a recruit should commence on the simplest form of target, that is the bullseye, and one should put into his hands the finest kind of sight possible for such a target, which in his opinion was the aperture. A recruit should next become proficient with a service sight on a bullseye target, and finally he should proceed to work on a target more nearly approaching service conditions (such as a picture of a khaki figure lying on a sky line between a bright green ground and a grey sky). In using figure targets, great care must be taken in the illumination. He had seen one range in which such a target was illuminated by a dirty metal filament lamp, under-run, and it was almost impossible to distinguish details on the target, the colour of the light being so yellow as to make the whole thing one blur. With an ordinary tungsten lamp of sufficient voltage much better results were obtained.

With regard to miniature ranges and the imitation of outside conditions, he had never seen one in which this was done. Mr. Trotter's arrangement at the Charing Cross range was probably the nearest approach to an open-air range. As to lighting the firing points, in his opinion the only admissible form of illumination would be completely indirect. It was true that in the open-air the sun shone on the back sight, but there were such different conditions that it was not at all fair to draw a comparison between this and the illumination at the firing point of a miniature range. Any bare light on a range at the firing point gave a line on the top of the back sight and produced fringes which were not solely due to out of focus effects. With indirect lighting this effect would be negligible.

Added :—

In view of the arguments of subsequent speakers I should like to add the following statements.

Several speakers maintained that the authorities were wrong in not equipping all rifles with aperture sights. Their experience, I believe, is limited to the bullseye and figure target. If, however, the aperture, as at present made, were tried on real service conditions, that is on a khaki figure lying under cover in an actual landscape, I do not think it would be satisfactory.

It is extremely hard to see a man, lying still, even with the naked eye. If now an aperture smaller than the pupil of the eye be introduced the light reaching the eye will be reduced, and it will be found that the colours are less vivid. I do not think it would be possible to find the man through the aperture. In case of open sight no reduction of light at all takes place above the bar, so that the method used is, keep objective in view and bring sights *up* till they are aligned on it.

Another speaker mentioned that for long range (16,00—2,800 yards) an aperture sight of sorts was fitted to rifle, and he used this as an argument that the authorities saw the advantage of this sight.

There are two reasons why an aperture is fitted in this case.

Firstly, it would be impossible to fit any kind on top of the barrel as the neck is stretched to a most uncomfortable extent when sighting up to 1,600, and though the ordinary sight is graduated to 2,000 nearly all people prefer the comfort of the aperture sight. The second reason is that for ranges above 1,600 it is quite certain that the aiming mark will never be a man or horse, and so it will only be used for aiming at a suitable landmark or feature of the ground. There is then no reason why such a landmark should be small, and it will probably be easy to select a large enough mark to be clearly visible through the aperture. Moreover, the long range fire is only used by considerable bodies to cause a danger zone and it is only the collective effect that is required rather than individual accuracy.

Another point regarding my argument about a line of light was the question of blacking the sights. Such a proceeding is forbidden by the regulations as being quite impracticable on service. The

surface of the sight is blued steel and should be used as issued.

Mr. P. J. WALDRAM said he had some small experience of miniature rifle ranges some years ago in conjunction with training recruits for the service rifle. In those days the miniature range consisted simply of an ordinary drill hall without any special illumination. It was found that if they could get the men up to Morris tube practice with the ordinary service rifle during the early months of the year, there was no difficulty in turning out creditable shots before the middle of the summer. He had also found that it was practicable to predict from a man's progress at the Morris tube range what he would do in the open. The lighting of the range usually was simply a series of unscreened arc lamps at the top of the drill hall. He had found, however, that when a smaller range was used, viz., a gallery which was screened from the general lighting of the hall and was locally illuminated in order that the targets might be seen, the majority of men would not shoot there under any circumstances.

As to glint on the back sight (which easily rubbed bright) many men at open-air ranges carried a box of wax vestas so that they could smoke the back sight or, more often, the fore; and some shots carried a box of black paint with them. The army musketry instructors always impressed the importance of a man training himself in the holding of a rifle at any odd moment at home. There was far more bad shooting through a man coming to a range with his muscles improperly trained for holding the rifle than from any errors in sighting.

Another curious thing he had noticed in open-air ranges was that some men shot well when the targets had been washed by rain and badly splashed by the clay soil splashing up on to the targets, although they were firing at a green-brown mass and merely had an idea that there was a bull somewhere about the middle. Even men shooting in wind and rain under these conditions could put up good scores simply because their muscles were well trained for holding the heavy rifle and they were able to pull off steadily whenever they wished.

Mr. H. BRAZIL said that being the Secretary of a Club having three ranges, he was very interested in this subject. The lighting of one of these ranges had been subject to a considerable amount of alteration since it was opened, at first one 50 c.p. lamp for each target was arranged on the floor about 3 ft. from the target with a reflector inclined slightly upwards was employed. Difficulties were at once experienced owing to the fact that the targets being attached to clips which were in turn attached to a wire rope did not always hang vertically, and when they tilted forward the illumination was very much reduced; to get over this difficulty and to get a more brilliant illumination (this being called for by the members) another 50 c.p. lamp was placed at each point slightly above the target and about one foot from it, this quite got over the difficulty of the targets tilting and, although some members have complained that there was too much glare, some very good shooting with orthoptic sights had been done at this range; on the other hand, he was inclined to think that the amount of illumination is too much for open-sight shooting.

He quite agreed with one of the other speakers that the conditions should be made as easy as possible for the beginner and that he should be allowed to start with orthoptic sights, the targets having the maximum amount of contrast between the bull and the card. By starting in this way the beginner would be quickly taught to aim properly, as he could see both fore sight and bull clearly with the orthoptic sight and he would be able to judge from the results obtained whether he had been holding the rifle steady.

He was also quite in agreement with another speaker in advocating the use of the orthoptic sight in actual warfare; it was acknowledged everywhere that shooting with orthoptic sights was 30% to 50% more accurate, and with such a resourceful enemy against us we could not afford to throw away such an advantage. Mr. Trotter had mentioned that for the efficiency test in Volunteer Training Corps the open sight was insisted upon

and apparently nearly all the shooting in these corps was done with the old form of "V" back sight which was from 3 to 5 m/m across the top. The back sight fitted in the latest Service rifles was of a "U" shape and only 1 m/m across the top which made it much easier to get the top of the fore sight on a level with the sides of the back sight as these were not off the edge of the card. He had had these back sights fitted to rifles used by members of his club and the improvement in the shooting was very noticeable.

With regard to the question of dark or light backgrounds for the targets, he was of the opinion that for orthoptic sights the dark background was a distinct advantage and the very high scores that were made on ranges with dark backgrounds confirmed this opinion. On the other hand where open sights were used he was not sure which was the better, and would prefer to keep an open mind until he had made further experiments.

In his opinion the use of a telescope to spot each shot was very essential, especially for beginners; it was useless for a man to fire off ten shots without knowing whether they were on the target until he had it returned to him.

Mr. Trotter had that evening very clearly explained and illustrated an experiment in the lighting of Rifle Ranges which he (Mr. Brazil) had had the pleasure of rigging up. Unfortunately, it was not possible to get this going until just a day or so before the meeting so that the time for experimenting was short. He had, however, induced several men to try the range and they all, without exception, had no hesitation in stating that they could see the back sight and fore sight much more clearly than was the case in a range where the firing point was kept dark. The scoring on this range with open sight rifles was, in some cases, markedly better than on the ordinary range. He ventured to suggest to Mr. Trotter that it might be an improvement if the lighting was graduated, the screen nearest the firing point having, say, two lamps, the middle screen four, and the target six or eight. He thought that Mr. Trotter was working in the right direction in attempting to imitate open-air conditions, especially as the real shooting would have to be done under these conditions.

Col. GAITSHELL BURR said that his personal experience of miniature ranges in London was that they were not sufficiently well lighted, but whether that was due to defective sight, he did not know. In some cases he found it difficult to see through the back sight properly. Some ranges are better lighted than others, but there should be special illumination of the whole range in order to make good practice.

There is also room for improvement in other ways, such as painting the surroundings white and keeping the lamps thoroughly clean, especially at the firing point.

Mr. FREAK, speaking with regard to the Charing Cross Range, suggested that a similar contrast between the target and the background might be obtained by putting the target against a light background instead of a black one, and doing away with the screens altogether.

Mr. W. J. BASSETT said he had done a good deal of shooting at miniature ranges during the past six years, and agreed that the use of the orthoptic sight was essential to good shooting. He could not understand why such great efforts should be made in making the rifle such a scientific weapon, and yet the facilities for using it were of the same nursery type as they were many years ago. This was singular, because he understood that some orthoptic sights were being used by sniping men at the front. It was also a fact that many men at the front, who were old Bisley shots, took their orthoptic sights with them, and their officers were giving them every encouragement to use them. They could be fitted to the service rifle without difficulty, but the authorities had never given facilities to rifle makers and sight makers to attach them properly to the service rifle. Similar proof that the authorities really recognised the advantages of the orthoptic sight was that the Mark I. rifle used in the South African War had this sight. With the use of the ordinary open sight, valuable time was lost in firing.

With regard to lighting the firing point, the difficulty was that if a light was behind, it was not in the right place, whilst if it was in front or on the right or left, it caught the eye. Semi-indirect lighting all round was an improvement. The closest imitation of daylight he had seen at a miniature range was at the Royal Automobile Club. The background was green, and there was a row of incandescent lamps at the bottom with arc lamp at the top, and the combination of the two produced a very bright light, but it was a very difficult range to fire on.

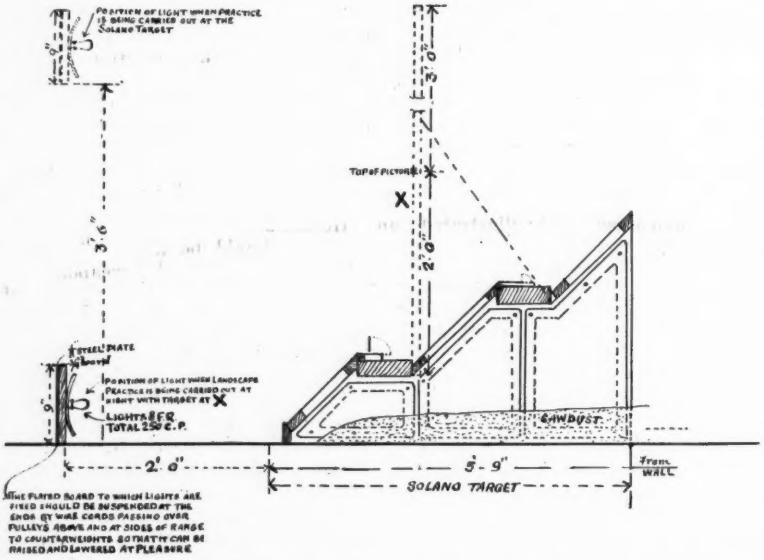
Mr. G. HERBERT referred to one of the pictures shown on the screen and stated that it was the rifle range of the Guildhall Athletic Club (Corporation of London); the illumination was 10 to 12 foot-candles and this result was obtained by using steel reflectors parabolic type 45°.

A double row of targets are used, being placed 2 ft. apart and approximately 2 ft. 6 in. from the ground and the same distance from the ceiling, and consequently the reflectors illuminated the targets with a direct ray at an angle of 45° from the vertical.

THE COMMANDANT OF THE ROYAL SCHOOL OF MUSKETRY, HYTHE (*communicated*) :—

OBSERVATIONS ON ARTIFICIAL LIGHTING OF MINIATURE RIFLE RANGES.

On miniature ranges the most suitable method of illuminating the target is to provide a number of incandescent gas, acetylene, or electric lights fixed to a $\frac{3}{4}$ in. board suspended horizontally by flexible wire cords at each end, and faced with pieces of $\frac{1}{8}$ in. steel plate in front of each lamp. The wire cords should be


POSITION OF LIGHT WHEN PRACTICE IS BEING CARRIED OUT AT THE SOLANO TARGET
TOP OF PICTURE
X
STEEL PLATE
POSITION OF LIGHT WHEN LANDSCAPE PRACTICE IS BEING CARRIED OUT AT RIGHT WITH TARGET AT X
LIGHTS PER TOTAL 250 C.P.
CHALK DUST
2' 6"
5' 9"
SOLANO TARGET
FROM WALL
THE PLATED BOARD TO WHICH LIGHTS ARE FIXED SHOULD BE SUSPENDED AT THE ENDS BY WIRE CORDS PASSING OVER PULLEYS ABOVE AND AT SIDES OF RANGE TO COUNTERWEIGHTS SO THAT IT CAN BE RAISED AND LOWERED AT PLEASURE

These reflectors were attached to ordinary batten holders, 2 ft. apart, fixed to a movable frame and placed at a distance of 2 ft. 6 in. from the face of the target to the centre of the filament of the lamp, the object of the movable frame being to vary the illumination according to the style of target being fired at.

carried over pulleys fixed to rafters or ceiling above and thence over other pulleys at the sides of the range, to counterweights heavy enough to balance the weight of the board, &c., and allow of it being moved up and down by hand, to suit the various positions of the targets. The positions proposed for the lights on a range fitted up with Solano and land-

scape targets are indicated on the accompanying print.

For the upper positions it may be necessary to arrange to tilt the board so as to throw the light down on the targets, and the protecting steel plates should therefore be deep enough to protect the lights even when the board is tilted.

In the case of gas a flexible length of tubing is required from the suspended board to the nearest point of the fixed gas pipe, and with electric light, a length of double insulated wire is needed.

To keep down the weight as much as possible, the length of the board should not extend beyond the targets to be illuminated, and when a 10 feet Solano target is used, the lights should have a total of about 250 candle-power and be fitted with good reflectors.

No specially powerful illumination is needed at the firing point, where one or two ordinary lights should suffice, as it is found that many men when firing prefer the lights near them, turned down or extinguished altogether.

Mr. Frank Bailey (*communicated*):—The utility of miniature rifle ranges is now so recognised that is seems incredible that only a short time ago it required the powerful assistance of the late Lord Roberts to obtain official sanction for the adoption of this method of teaching Young England to shoot. Many Army authorities now agree that 75 per cent. of all there is to be taught in shooting is capable of being learned on a miniature rifle range. The knowledge of how to handle a rifle, aim and fire correctly, is so important that although the indoor ranges do not in any way attempt to reproduce practical conditions the result of the movement has been most beneficial. During the last year I have had the opportunity of forming this opinion as the result of establishing a miniature rifle range with about 250 members.

Mr. Trotter has opened the discussion on this subject so admirably, and speaks from actual experience, that I can proceed at once to matters of detail.

An indoor range cannot of course reproduce the actual conditions of wind and light variations, but an open miniature range of, say, 100 yards can give experience in these matters.

The lighting of an indoor range is an easy matter to carry out, and it does not seem necessary to limit the illumination provided it is well diffused and there are no harsh lines or brilliant beams of light.

A target with a black bull on a white ground is easier to hit than a white bull on a black ground.

In using the orthoptic sight most shots prefer to have the firing point dark, but with open-sight it is essential to have light at the firing point in order to be able to see the sights of the rifle.

If the range is dark, with the exception of the target, we have found that sources of light should be screened from view in order to prevent distracting rays from crossing the line of sight, and in illuminating the target it is better to place the source of light below the target, thus throwing the light upwards.

As regards the use of the orthoptic sight, it has been stated that this results in a 10 per cent. improvement in shooting, and the attachment which is now made in a handy form by The Birmingham Small Arms Factory does not appear to be very much more fragile than the existing sights; we can, therefore, hope that the authorities may eventually recognise and approve of the use of the orthoptic sight.

It has always seemed to me that the miniature range has suffered from the erroneous impression which many people seem to have that it is a sort of toy, and does not reproduce practical conditions. The use of small and light rifles possibly gives some ground for this impression, but if we can practise with full size service rifles (but with a small bore) and preferably with bayonet attached, we not only get used to the actual weight of a rifle but the shooting is also improved, the only thing missing being the "kick" which is so often found with unpleasant results when service ammunition is first tried on an open-air range.

The physiology of the eye, and the difficulty many people find in adjusting their eyesight, is very clearly explained by Mr. Trotter, and I venture to think that some of these difficulties can be realised, and to some extent overcome, by practice, by experimenting with ordinary dioptric prismatic binoculars with adjustment for each eye; then, by looking at an object with one free eye

and the other through the field glass, it will be found that although at first there is some difficulty in obtaining the necessary muscular control independently of each eye, yet with a little practice this can be accomplished, and the rifle can then be handled with more confidence without the necessity of screwing up one eye and suffering from a sort of astigmatism.

The present war is apparently showing that the firing distance is frequently as short as 200 yards, and there must therefore be some difficulty in getting the shots low; but as the bayonets are always fixed perhaps this will keep the muzzle down.

Any pastime or work which improves efficiency must clearly be good, and I can testify to the fact that the use of an indoor miniature rifle range has great possibilities in improving physique, methods of breathing, the use of the eyes, and general steadiness. We all know the story of the young recruit who, when taken to the butts, was directed by his sergeant to fire at 1,000 yards, with no apparent result: he was then taken to the range at 500 yards, still with no result; then at 200 yards with no hit, and on the range being shortened to 50 yards without result, the by that time exasperated sergeant yelled, "Fix bayonets and *charge*—for that's the only way you'll get there."

Mr. SYDNEY G. CORAM, Instructor of Musketry (*communicated*):—This is a matter in which I am very much interested, as I have always felt that miniature ranges are very badly lighted.

I am strongly opposed to all the light being thrown on the targets, and the firing point kept in the dark, because this is directly opposite to ordinary conditions.

I would suggest where it is possible, that a miniature range should be fitted with hidden lights both sides of the range about 12 inches from the ceiling or some similar arrangements of diffusing light as near as possible to daylight. I am of opinion that every opportunity should be taken to teach and correct the method of holding a rifle, aiming and firing on the range; of course, I am speaking from a strictly military value point of view, and feel that all the conditions should be made as near as possible to those under which men would have to fire when on active service.

I have continually found that men who have been used to miniature ranges where the firing point is kept dark, have shown considerable difficulty in getting correct aim upon their first appearance on an open range, and invariably complain that the light on the foresight or backsight blurs their visage.

I don't think there are any other points that I desire to put before you, and must express my regret on being unable to attend your meeting.

Mr. T. BERNARD PICKARD (*communicated*):—Personally I consider that there is undoubtedly a degree of illumination of the target which gives the best definition of the bull.

I strongly believe in a neutral background to the targets preferably tending to green and fairly illuminated, and, of course, the sources of light concealed.

The firing point, I consider, should be illuminated, but by diffused *reflected* light the source again being screened (otherwise I think a darkened firing point is preferable to direct sources of light).

Under these conditions I think that an artificially illuminated range may offer opportunities for practice in no great degree less than those available in an open-air range.

Mr. J. G. CLARK (*communicated*):—

SOME EXPERIMENTS MADE ON THE RANGES OF THE GAS LIGHT AND COKE CO.

As bearing on the question of the relation between intensity of illumination of targets and accuracy of fire, I thought an account of some observations and experiments bearing upon certain practical phases of the problem might be of interest. It is realized that they only touch the fringe of the question, but so far as they go they throw some light on certain aspects.

Two experiments on a 25 yards range were made with the following results.

Six targets, the surface brightness of which differed from 4·5 to 45 foot-candles, were fired at by each of six firers, each firer firing ten shots at each target. The following scores were recorded:—

Targets (25 yards range).

Firer.	No. 1. 4·5 ft.-candles.	No. 2. 7·5 ft.-candles.	No. 3. 16·5 ft.-candles.	No. 4. 20·0 ft.-candles.	No. 5. 40 ft.-candles.	No. 6. 45 ft.-candles.	Total scores.
A ..	92	92	87	91	86	91	539
B ..	94	93	95	95	91	93	561
C ..	87	88	86	90	86	89	526
D ..	86	90	81	90	90	91	528
E ..	89	100	95	98	96	93	571
F ..	91	85	83	92	90	90	531
Average	89·8	91·4	87·8	92·6	89·8	91·2	90·4

The aiming was throughout corrected by telescopic observations of the targets.

At the end of this experiment five men expressed a strong preference for No. 4 target and one for No. 3. It will be observed that the highest total score was made on No. 4, although this was not known when the men expressed their preference for this target, but the maximum and minimum totals differ only by about 5%, so that no very fine distinctions can be made.

In the second experiment the conditions were the same, except that the aiming was not corrected by telescope, the firer being advised of the position of his *first shot only*, the idea being to eliminate any possibility of the firer automatically and deliberately correcting for erroneous aim. It was thought that this procedure would have given a more reliable idea as to the pure question of visibility; it is *not* suggested that correction in practice should *not* be made; on the contrary, the firer should I think be trained to make proper allowance for errors due to light just as he must acquire the habit of making allowances for wind, etc., and should therefore be advised as frequently as possible of the placing of his shots.

The following is a record of the results:

Targets (25 yards range).

Firer.	No. 1. 4·5 ft.-candles.	No. 2. 7·5 ft.-candles.	No. 3. 16·5 ft.-candles.	No. 4. 20·0 ft.-candles.	No. 5. 40 ft.-candles.	No. 6. 45 ft.-candles.	Total scores.
A ..	93	91	97	91	87	88	547
B ..	92	91	83	89	89	94	538
C ..	98	87	88	93	92	83	541
D ..	90	95	96	98	99	92	570
E ..	88	86	95	83	87	83	522
F ..	85	90	93	89	93	92	542
Average	91	90	97	90·5	91·2	90·3	90·6

The aiming was not corrected by telescopic observations.

Here the difference between the maximum and minimum scores is less than 4%, so that it seems safe to infer that within these particular limits of target brightness the visibility is the same. The targets were of the circular type with black rings and bull on fairly white cards. Below is given an account of two experiments on 50 and 100 yards ranges, under artificial lighting, the sources being completely screened from the firers and the target surroundings being practically black.

The firers in each case were advised of the position of their first shot only.

From the scores it appears that the experiments at 50 and 100 yards confirm the conclusion arrived at from the experiments at 25 yards—namely, that within the limits of 6 and 40 foot-candles (surface brightness of white part of target) there is no appreciable difference in visibility. It is interesting to note, however, that something between 10 and 20 foot-candles had almost unanimous approval. Anything higher than 20 was regarded as dazzling, the surroundings being dark in every case.

It is not unlikely that a closer examination of the targets might disclose certain differences. For instance in reckoning the scores, a score of say eight at the top of the target is taken as of the same value as eight at the bottom, although their actual positions on the target were of

Target (50 yards range).

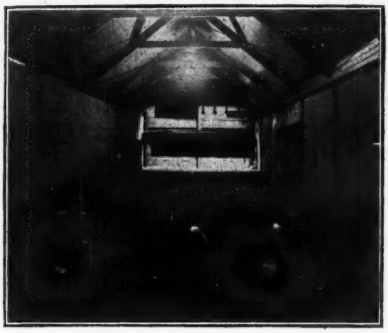
	No. 1. 6 ft.-candles.	No. 2. 40 ft.-candles.	No. 3. 17 ft.-candles.	No. 4. 10 ft.-candles.	No. 5. 17 ft.-candles.	
A	92	91	90	91	93	457
B	85	88	92	85	90	440
C	92	95	92	94	91	464
D	98	99	96	99	96	490
E	94	94	97	93	90	468
Average ..	92·2	93·4	93·4	92·4	92·4	92·7

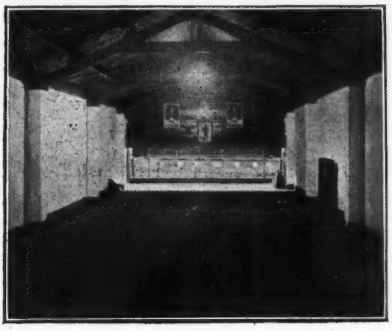
Target (100 yards range).

Firer.	No. 1. 3·5 ft.-candles.	No. 2. 8·0 ft.-candles.	No. 3. 13·5 ft.-candles.	No. 4. 6·0 ft.-candles.	No. 5. 9·2 ft.-candles.	Totals.
A	91	91	94	93	89	458
B	94	90	93	88	96	461
C	95	91	92	94	96	468
D	89	89	90	95	87	450
E	85	82	89	90	85	431
Average ..	90·8	88·6	91·6	92·0	90·6	90·7

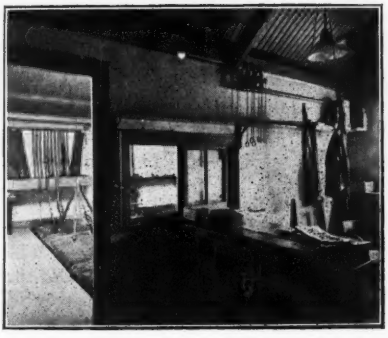
course some distance apart. Should any member be sufficiently interested I should be pleased to lend him the targets to enable him to make a closer analysis.

had experience on open and closed ranges, there does not seem much in it. It seems that proficiency at one means proficiency at the other. This perhaps is not surprising when we remember the wide range

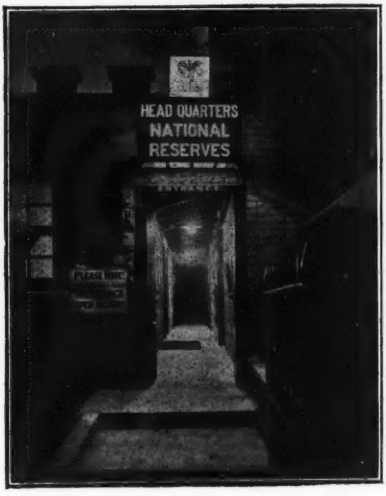




Views of gas-lighted ranges. (The light hanging from the roof is screened when firing is going on.)



Showing central control of all lights in the instructor's office by means of chains beside table.



Use of gas-lighted signs outside the range.

Photographs of Gas-lighted Range. (*Mr. J. G. Clark.*)

It might seem as though the use of targets artificially lighted with dark surroundings introduces a condition which does not exist in practice, but from inquiries I have made of men who have

of adaptability of the human eye, and the further fact that illumination is only one factor of many that contribute to the accuracy of the firing, some of the more important of the others being, the use and

adjustment of sights, the art of trigger pulling, and the steady handling of the rifle, to say nothing of instruction in the general care of the weapon, all of which can be efficiently taught at closed ranges with artificial lighting.

In conclusion I have to acknowledge the assistance of the Gas Light and Coke Co. for the use of their ranges for these experiments, and also to the firing parties who so kindly placed their services at my disposal.

Dr. W. ETTLES (*communicated*):—The first phenomenon mentioned by Mr. Trotter is one which, as yet, has had very scanty attention given to it, and seems to be unknown to many writers on physiological optics. So much is dealt with on the assumption that an out-of-focus image of a luminous point is "a diffusion circle," basing our calculations and constructions on the result of optical bench experiments, that the fact that the image formed on the retina is produced by refractive media quite different from any dead or inorganic substances is ignored Yet the reader of the paper tells us very clearly that it is not so much a blurred image which annoys him as "multiple and uncertain images." Two writers only have dealt with this "polyopia monocularis" of the *normal* eye as something requiring careful study—Prof. Tscherning and the late Mr. Shelford Bidwell. Both agree that they are caused by the sectors of the crystalline lens having different refractive indices and by the fibrous structure being developed as age advances. Bidwell's experiments, by which he reproduced multiple images by the interposition of a gauze screen in front of the lens, are most instructive.

That shooting taught in an indoor range cannot make the learner accustomed to allow for the effect of wind, quivering haze, density of atmosphere (a Bisley shot alters his elevation with the barometer) and the like, is self-obvious: he cannot learn to judge distance, half the battle in individual shooting, and might degenerate into a mere show performer with a pea rifle; in spite of all this, practice at the miniature range is of the utmost value in laying the foundation of a marksman's education.

Aiming demands a swift to and fro accommodation for, and a maintained impression of, the several sights and the object. Hence presbyopes are severely handicapped, as the paper shows. The clear perception of a near object varies with its illumination and in presbyopia that is markedly the case, as is seen in the characteristic way in which a person whose glasses are mislaid will take a letter close to a lamp to read it. I have been engaged every Saturday evening throughout the winter in teaching shooting at a covered range, and I found it was only the presbyopes who complained of inadequate illumination of the rifle sights. When a bright cross light was thrown on the position occupied by the firer the shooting of the older men greatly improved, and still more when the lengthening day permitted practice in the open. A pin-hole disc placed in front of the eye is of great help, and I know of no valid reason why it should not be used. After all, older men are learning to shoot with the one object of killing invaders and not of hunting for pots. A pin-hole increases accuracy and lessens ammunition waste. It is not at all necessary to have special "peep sights" fitted, as for match rifles, all that is needed is a little cardboard shade fastened with an elastic band, and bearing in its centre a hole about 1 mm. in diameter.

Irradiation is, theoretically, a factor in diminishing visibility, but practically it is impossible to get sufficient light to cause any sensible encroachment on the official bull's eye. Its size (2 inches at 25 yards) precludes this. Small black points would disappear under conditions where large discs are not perceptibly affected. I found that if the surroundings were too dark the illumination became annoying by reason of the increased adaptation and retinal sensibility. The result was that a glance at the bright target soon produced a strong negative after image which, being superimposed on the retinal picture, degraded it very much. These after-images were practically done away with by increasing surrounding light and so lessening retinal sensitiveness. The rôle of the pupil is negligible compared with that of the retina. When learners become reliable shots it is important to teach them

shooting at objects under lessened contrast. This is easily done by ordering the firer to wear dark smoked glasses —much less trouble than altering target and lights. Any *naked* light lying within ten degrees of the visual axis causes much complaint from shooters who are always anxious to find some reasonable explanation for a poor score. If the light is brilliant it is impossible to shoot well—indeed, in defensive operations the power of blinding an enemy by direct searchlight is often utilised.

My own experience is that a bright light on the card is essential and that one can hardly have it too bright if the range is generally lighted to a moderate degree. General lighting is necessary to enable men to move safely with loaded arms, to find ammunition and dispose of empty cases, to ascertain if anyone has got in the danger area, &c. For all, and especially for older men, a good cross light should be thrown on the firing position, but the metal sights should be blackened as any bright facet acts as a luminous point. The usual mounting for cards makes it difficult or impossible to see bull's eye shots—those on the white card show up as black spots, but the black apertures on the black disc can scarcely be seen with a telescope. It is often essential that a pupil should know exactly how he has amended a previous aim and the point was got by whitewashing the iron back plate and so arranging the light that part of it was used to illuminate this plate. "Bulls" then showed up as white points—"outers" were rendered less visible, but could still be clearly seen. The definite knowledge that he has scored a bull is a great incentive to a beginner to put his best into the succeeding shots.

The List of Queries (see p. 250) was submitted to the COMMANDANT at the DEPOT R.M., DEAL, who writes as follows :—

"The experience obtained at this depot of artificial light in shooting galleries is somewhat limited, as all work in connection with the preliminary musketry training of recruits is done by daylight, and artificial light is only used for the purpose in the evenings.

"In the absence of electric light in our gallery, three incandescent gas burners of 60 candlepower are used, one over the heads of the firers, not screened, and two in front of the targets, one at each side, screened from the firers' view ; in addition there is one Welsbach light of 120 candlepower over the centre of the targets in line with the other two lights and also screened from view.

"The answers to the questions in enclosed paper are given below :—

"(1) No. After the first few preliminary practices, when conditions should be as simple as possible, the object should be to reproduce practical conditions as far as possible.

"(2) No ; but the object should be to fulfil the conditions laid down in (1).

"(3) Yes, to a large extent. With or without artificial light it is impossible to reproduce natural conditions in a shooting gallery.

"(4) Excessive illumination certainly does lead to irradiation, but it is impossible to say from experience obtained here what the permissible limit of illumination should be.

"(5) A dark background is not used for our targets.

"(6) (*a*) It improves it. (*b*) Improves it in most cases. The majority of men prefer to do without the overhead light, but some of the National Volunteers who have been using our gallery recently, and who are, of course, much older men than the recruits, find that they cannot see the sights without the overhead light.

"(7) Yes, certainly after the preliminary practices.

(8) (*a*) A good alternative lighting arrangement is one in which the lights are at the end of the gallery behind and above the targets, with reflectors throwing the light down on to the targets and at the same time screening the light from the firers. (*b*) I cannot say.

"(9) Yes. If the ceiling of the gallery were suitable some system of reflex lighting might be tried with advantage.

"(10) No experience has been obtained here."

Mr. FRANK WEST (Hon. Secretary of the Rifle Club at the India Office) (*communicated*) :—

The chief object of a rifle range is to afford opportunity to unskilled shots to become good marksmen, and also to give practice to trained shots living in crowded localities (who could not otherwise obtain such practice), in order that their skill may be maintained, if possible, improved.

The ideal light for shooting is daylight, subject, of course, to certain restrictions regarding the position of the sun, &c. In most ordinary basement ranges it is impossible to use daylight, and in certain parts of the year even ranges above ground must be artificially lighted during shooting hours.

The use of artificial light seems to make skilful shooting more difficult, and the difficulties seem to increase with advancing age.

With the open sights there is little or no trouble in daylight, but on an artificially-lighted range one main defect is that the bull's eye becomes hazy and less clearly defined. If there be this difference then the defect is clearly due to the artificial light. In what does the defect consist ? Is the intensity of the light insufficient ? The defect is generally remedied by the use of a peep-sight which seems to point to the mode of lighting the target, and not the intensity of the light as being defective. On an artificially-lighted range some shooting takes place with a lighted target and utter blackness at the firing point; some shots, however, do not mind their rifles being in the full glare of the light. I have even seen good shooting on a range where the targets were more poorly lighted than the firing point, the shooting taking place in the full glare of an overhead light.

It seems to be generally admitted that keenness of vision is favourably affected by having a dark background to the targets, the source of light illuminating the target being concealed from view.

I am of opinion that if the artificial conditions of lighting could approach those of the open air, then range shooting would reach the ideal stage.

Mr. J. S. DOW (*communicated*) :—

I have had the privilege of visiting a number of rifle ranges in London in connection with this discussion. The usual method of lighting consists in strongly illuminating the targets by concealed lamps, the firing point being left in complete darkness. In general the amount of illumination on the target appeared sufficient, readings from 8—15 ft.-candles being recorded. I have been told of provincial ranges where the artificial lighting was much less satisfactory, *e.g.*, the use of bare lamps at intervals down the sides of the range or of naked flickering gas-jets, the burners of which obviously needed attention. It will be generally agreed that marked defects of this kind should be avoided.

On one range visited it happened that, owing to derangements in the lighting, three successive targets had illuminations of approximately 10, 20, and 50 ft.-candles. My impression of the effect in this case bears out the view expressed by Mr. Blok and Mr. Clark, that 20 ft.-candles is ample for ordinary targets, and 50 ft.-candles excessive.* Certainly the white background on the target receiving 50 ft.-candles appeared to encroach on the bull, although this effect disappeared when the target was viewed through an orthoptic sight. With the ordinary open sights there was also a tendency to blur. With the lower illuminations the bull was decidedly clearer.

There seems little doubt that personal impression plays an important part in this matter. I have found that people with short sight are more apt to experience blurring, due to excessive brightness, than those with normal vision. Slight inflammation or watering of the eyes has a similar effect.

No doubt the high standard of eyesight required in the Army renders the effect of defective illumination less marked among recruits than among members of volunteer corps, whose vision is in general less perfect. But it is evident that even for people having normal vision there is a limit to the desirable brightness of targets. I believe it is generally considered impracticable to sight on the flame of a

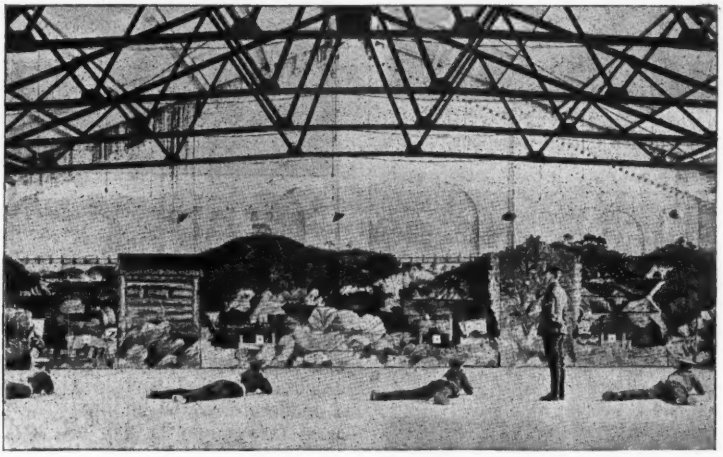
* As the term foot-candles frequently occurs in this discussion a definition of this term is given on p. 281.

candle amid dark surroundings, and a marksman who attempts the feat of shooting off the wick has to rely on a pot shot. Now the brightness of a candle-flame is about the same as that of a white target receiving 500—1,000 ft.-candles, so that it is not difficult to believe that many people would find a brightness of 50 ft.-candles excessive. It is common knowledge that a fine wire cannot be seen against an unduly bright background.

Another important point to recognise is that this glare-effect is intensified by the dark surroundings. A marksman finds no difficulty in aiming at a target on an open range, receiving full sunlight and illuminated with an intensity of perhaps 2,000 or even 5,000 ft.-candles. But he would certainly find such a brightness intolerable in a dark room. There seems little doubt that the expansion of the pupil aperture in a dark room diminishes the acuteness of vision of many people whose sight is imperfect; so far as his short experience of the matter goes, this is true for my own eye. I am also conscious of the "after-image" effect which was described by Dr. Ettles, and occurs when the gaze is shifted from the target to the adjacent darkness.

For these reasons it appears reasonable to suggest that the contrast between the brightness of the target and its background should not be severe, and that complete darkness at the firing point should be avoided. Mr. Trotter has mentioned that he shot better on an outdoor range than on one illuminated in the usual artificial manner (see p.254). When visiting this outdoor range with Mr. Trotter I measured the contrast between the white target and the dark boards behind it and found the ratio to be about 8 : 1, while the contrast between the target and the grass foreground would be very much less. On the other hand, the illumination of the walls in the average artificially lighted range is usually too low to measure, and the contrast may exceed 1,000 : 1.

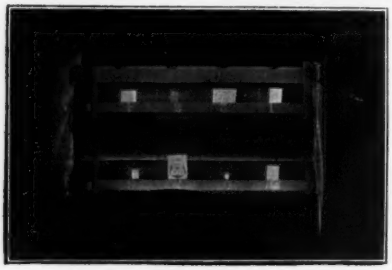
During a recent conversation with an officer who has trained a considerable number of recruits on two similar ranges, lighted respectively by natural and artificial means, I was informed that better results were usually obtained by the men who shot in daylight. On the other hand, a private in Kitchener's Army told me that of the men in his battalion a considerable proportion of those who



Reproduced from Part 2 of the Musketry Regulations (Plate 51) by permission of the Controller of H.M. Stationery Office.

Miniature Cartridge Range, R.E. Depot, Chatham.

had attained proficiency on an artificially lighted miniature range failed completely when promoted to work on an outdoor service range, and had to return to the miniature range for further training. In a few cases men had even to be discharged because they never attained proficiency on the outdoor range. Does not this suggest that the peculiar conditions on some artificially lighted ranges are not a good preparation for work under service



Range at the Guildhall (mentioned by Mr. G. Herbert).

conditions? The question of the comparative effects by natural and artificial light well deserves study, and it would be interesting to collect opinions from a number of officers who have had practical experience of the subject.

In the illustration on p. 279 I am reproducing, at Mr. Trotter's suggestion, a

Range of the City of London National Guard, Blackfriars Bridge.

view of a miniature range which occurs in Part 2 of the Musketry Regulations (Plate 51). Permission has been kindly granted to the Society by the Controller of H.M. Stationery Office for this picture to be reproduced. The conditions shown in this photograph, taken evidently by daylight, surely approach much nearer to practical conditions than would be the case were the artificial light derived from the suspended lamps to be employed.

Range at the Polytechnic, Regent Street.

The chief reason assigned for darkening the firing point is that inconvenient reflections from the foresight occur when artificial illumination is used. But such reflections are merely images of exposed bright sources. If concealed lighting, and a moderate degree of illumination were used they might be avoided, and there would be the additional advantage that the instructor could see the attitudes of those firing and correct any incipient faults.

Mr. A. P. TROTTER (*communicated*), summing up the discussion, writes:—It has been my privilege to stimulate and perhaps to provoke a discussion rather than to attempt to teach or to dogmatize, for it has been clear that almost every speaker has had a longer experience than mine.

The wide range of interests covered by our Society has enabled it to investigate a matter which seems to be remote from its professed objects. Members have reduced to definite measurements the

intensity and the distribution of illumination and the surface brightness, and have given detailed description of many miniature ranges and have examined the physiological conditions which affect the question.

Mr. Blok's proposal to use a surface brightness of about 5 foot-candles for the background and 10 for the target seems to be a good one. It would be sufficient to show the top of the backsight and would, perhaps, allow attention to be directed to the target better than a white background. In reply to his question about the experimental range which Mr. Brazil had kindly arranged several members have reported that they had found considerable improvement, although the illumination of the targets happened to be about half that of an ordinary range.

Mr. Freak refers to the light background of this range. This might be applied to any range by the use of whitewash, or colour wash as recommended by Mr. Bernard Pickard. The intermediate screens are intended to flood the eye with diffused light, for the purpose of contracting the pupil, as in daylight. Naked lights would be intolerable.

Mr. J. G. Clark's painstaking records show that great latitude is permissible in the illumination. In comparing open and closed ranges he says that proficiency at the one means proficiency at the other. No doubt proficiency at the closed range is generally but not always associated with proficiency in the open. I am quite sure that there are many who, like myself, find that they can make good work on a daylight range and very bad work at a dark one where the targets only are illuminated.

Dr. Ettles confirms the observations which I made with some diffidence, about the multiple images and about the special difficulties of men who have reached middle age. His proposal to show up hits on the " bull " as bright points is a very good one. It would be encouraging to a beginner, but it may be difficult to carry out.

Mr. Brazil referred to some matters connected with aiming. The " U " sight is undoubtedly an improvement on the " V " for deliberate firing, but for rapid it needs a little practice, as it is so small that it is not easy to see. He emphasizes the important matter that rifle shooting is to be learned by successive steps, and that these should be made as easy as possible for the beginner. Whatever objections there may be to orthoptic sights either for passing qualifying tests or for warfare, Mr. Brazil appears to be justified in recommending them for the beginner, who would thus gain confidence even if he felt, as I did, that practice with such sights would be lost time because they would not be allowed afterwards. Mr. Brazil does well to point out the uselessness of firing for practice without " spotting " or coaching.

Mr. A. Schamasch supports Mr. Brazil in recommending that the recruit should have troubles removed as much as possible from the start, but he does not extend this to the use of aperture sights or to the blackening of sights.

Other writers and speakers have taken part in a discussion which, though directly interesting to a small proportion of the members of the Society, must be gratifying to them all as a useful contribution to the struggle in which we are all engaged.

THE " FOOT-CANDLE."

(See footnote on p. 279.)

For the benefit of those who are not familiar with illumination measurements it may be well to state the meaning of the above term, which frequently occurs in the discussion.

A foot-candle is the illumination received from a source of one candle-power falling perpendicularly on a surface at a distance of one foot from the source.

Surface brightness is also expressed in foot-candles, and is generally assumed to be the brightness of white cardboard receiving an illumination of one foot-candle.

A SUMMARY OF VIEWS ON THE LIGHTING OF RIFLE RANGES.

THE answers to many points in the *List of Queries* (referred to on p. 250) are at present incomplete and in many instances only tentative suggestions can be made. The following is intended to represent a summary of the views expressed in the discussion on the subject and to indicate points on which further information is desired.

(1) A miniature range is intended mainly for beginners, and to enable learners to acquire the elements of the art of holding a rifle, aiming and firing. Naturally, experience of many matters, such as judging distance, the effect of wind and varying atmospheric conditions, &c., can only be obtained afterwards in the open.

(2) Conditions should therefore be made as simple and easy as possible, and if the use of light mainly to illuminate the target simplifies the conditions, this course should be followed. However, after a certain amount of practice, learners might make use of pictorial targets, and possibly arrangements might be made to enable the conditions to be altered in other respects to approach more nearly to practical conditions.

(3) Some consider that firing on artificially lighted ranges, as at present arranged, conduces to skill in a specialised and artificial type of shooting ; but it is also suggested that any habits so acquired are quickly corrected in the open. Further information is needed on this point.

(4) It appears that the eye can adapt itself to widely varying intensities of illumination, but the power of adaptation is probably less among older men. Some people, undoubtedly, experience a loss of definition and an impression of glare if the illumination exceeds a certain value. An illumination less than 5 foot-candles seems to be exceptionally low and probably insufficient. For a black and white target an artificial illumination of 15—20 foot-candles is considered comfortable ; 50 foot-candles is apt to be dazzling. For pictorial targets 20—30 foot-candles is suggested.

(5) Experience differs as to the effect of a dark background to the target. To a young man with good vision, the difference so caused may not be great. Some people, however, find that severe contrast prejudices ease of aiming. A moderate contrast appears preferable, but the point requires further elucidation.

(6) Many speakers express the view that complete darkness in the range, and light concentrated only on the target, are not desirable. Methods of obtaining a moderate, well-diffused general illumination are recommended, and it is suggested that indirect lighting should be used, especially at the firing point.

(7) Targets in which the contrast between bull's-eye and card is less than that obtained by printing black on white may be used by those who have first gained experience with the ordinary variety. In the case of pictorial targets attention should be paid to the *colour*, as well as the intensity of the light.

(8) No unscreened bright lights should be visible from the firing point. There is not sufficient evidence to indicate whether better results are habitually obtained by daylight than by artificial light. But this appears to be the personal experience of many men who are advancing in years, and may also be true for some young men.

(9) See (2) and (6). Some hold the view that a nearer approach to natural lighting conditions is desirable and would make shooting easier. The methods to be adopted in securing these conditions require further study.

(10) Some illumination at the firing point is desirable in order to enable moving targets to be manipulated, and assist the instructor to watch the actions of men firing. If indirect lighting is used it should be possible to avoid inconvenient reflection from the sights. Suggestions would be welcomed for improved means of observing and recording results. The lights should preferably all be under the control of the instructor.

[*It is proposed to appoint a Joint Committee to deal with the unsettled points revealed in the above summary, with a view to preparing a Specification for the Lighting of Rifle Ranges.*—ED.]

PROFESSOR D. A. LOUIS.

In the death of Professor D. A. Louis, on March 25th, the country has lost a man of wide scientific attainments and exceptional personality.

Professor Louis was almost equally well known in the scientific world and in journalistic circles. In the earlier part of his career he studied chemistry, physics and metallurgy at the Royal School of Mines, and he was subsequently engaged on agricultural research in connection with some important experiments by Sir John Lawes.

Later he accepted an appointment in Colorado, where he gained practical experience of mining, and in subsequent years he practised as a consulting mining engineer, and paid visits to most of the mining districts in Europe and the United States. In 1893 he became an assistant examiner to the Board of Education, and in 1900 he was Professor of Mining at the Yorkshire College, Leeds.

Professor Louis also devoted attention to petroleum, visiting the oilfields in many parts of the world, and taking an important part in the Third International Petroleum Congress at Bucharest in 1907. His wide international knowledge and experience proved of great value in connection with several congresses of recent years. In 1910 he was Hon. Secretary of the Metallurgical Section of the Seventh International Congress of Applied Chemistry. For many years he was Foreign Representative of the International Association of Journalists.

As a writer he possessed a remarkable power of grasping the essentials of a subject at short notice and his wide scientific knowledge was never at fault. He was the author of many papers before scientific societies and articles in encyclopædias and various technical journals. His style was incisive and he was generally recognised as an excellent reviewer. Yet, though he did not hesitate to condemn faults, no one was readier to recognise and appreciate true merit.

Professor Louis took an interest in the work of many institutions. He was also a member of the Illuminating Engineering Society. On more than one occasion he proved a good friend to the Illuminating Engineering movement by his support in the Press, and up to the very end he expressed a great interest in its progress.

The writer, in common with all who knew Professor Louis, will long cherish a remembrance of his genial and kindly disposition, and the touch of whimsical humour which made him so delightful a companion. His loss will be deeply felt by a wide circle of friends.

LEON GASTER.

THE ARTIFICIAL LIGHTING OF MOVING PICTURE STUDIOS.

By William A. D. Evans.

As the time has now arrived when increased output of moving pictures is demanded from the manufacturers in this country, and as this is almost entirely a question of artificial lighting, some facts as to what has been done in the United States, where the production of pictures in large quantities has been for some time a highly organised business, may be welcome. This business now ranks as the fifth industry of the country. It includes the production and manufacture of the films, the exhibition of them and the accessories necessary for the exhibition.

Everywhere, the motion picture has been elevated from the position of being only a "side-show" and is more than competing with the ordinary theatres. It might almost be said that the moving picture was a daily necessity.

The majority of "picture fiends" have naturally become interested in the different actors and the various producing companies; and by the introduction of feature plays and serial films, each of the various companies is endeavouring to build up an individual following.

Twelve years ago there were probably only five studios for the production of films where there are now more than one hundred. The large amount of money which has been made in this industry and the possibilities of future profits has drawn capital for the formation of new enterprises from various sources, and with the creation of so many new companies, competition has become keen, and the cost of producing films has become an important factor.

In the making of a picture the costs may roughly be divided into:—Cost of raw film; interest and depreciation charges on buildings and equipment; salaries of actors, directors and mechanics; cost of developing and printing and the cost of lighting.

Just what relation these various costs bear to one another is doubtful, but it has been stated that in the United States completed films cost to make anywhere from two shillings ($.50) to a pound ($5.00) a foot, the average being approximately eight shillings ($2.00) per foot.

The raw film itself costs approximately 1¾d. per foot for the negative and 1½d. per foot for the positive. Naturally the highest cost is for labour, and in this respect the moving picture industry does not materially differ from many other manufacturing processes. Any way in which labour costs can be kept down and labour utilised to its fullest capacity, is bound to decrease the cost of the film and increase the profits of the manufacturer.

One item which tends to help utilise labour to its fullest extent is proper light. The first maxim in the moving picture studio is that "no picture can be made without proper light and plenty of it." Sufficient light has to be provided, whether it be daylight or artificial light, to take clear pictures in approximately 1/50 of a second. They must be taken with detail, as they are projected to a magnification of about 150 diameters on the screen, and the public is becoming more and more critical regarding proper definition of the subject projected.

The stop used is generally about F 4·5, with a 2-inch lens, and if there is not an abundance of light, the picture will not be satisfactory when the camera is working at the required speed.

The first indoor studios depended on daylight for their lighting by the use of overhead glass skylights; later, studios were constructed not only with overhead lighting, but with the sides also of glass. Even under these conditions, on rainy and cloudy days, or about three o'clock in the afternoon during the autumn and winter months, the daylight available was insufficient to produce good pictures.

At about this period the Cooper-Hewitt lamp had been developed, and its high actinic values were justly appreciated by the few studio managers who were then in the business, and an installation of these lamps was made in 1905 at the Biograph Company's original studio on the 14th Street, New York City. From this installation has come the practical development of the Cooper-Hewitt lamps for the moving picture stage.

Few people who see the films on the screen appreciate what has to be done to take even the simplest scene, after a scenario has been accepted by a company and turned over to the producer who is the successor of the stage manager. The actors must be selected for the various parts and given instructions; scenery must be found for the setting, or, if necessary, new flats, etc., painted, and erected on the stage. The necessary "props" must be got together, and after rehearsing the scene time and again until the producer is satisfied, he calls for "Lights" and then for "Camera," and the picture is taken. Fifty or sixty feet of film, which requires about one minute to photograph, may have taken two or three hours to rehearse. All scenes

occurring in the same set are generally taken one after another irrespective of how they occur in the scenario, and after developing, the sections of the films are jointed together in their proper places.

In setting a scene, conditions are different from those in a theatre, inasmuch as a scene is not played over a rectangular stage, but on one in which the stage is built like a triangle, so that the scene will occur within the angle of the camera lens. Inasmuch as the height of each picture on the film is about $\frac{3}{4}$ inch and the width one inch, the angle for height varies from that for the width. Figures

On most stages the front line is approximately 8 to 10 feet wide, and has the camera 15 feet in front and the lens at a height of about 4 to $4\frac{1}{2}$ feet from the floor. The average depth of stages for small sets is anywhere from 10 to about 15 feet back of the front line. A large stage may extend upwards of 32 feet up, back from the front line.

Not only is it essential that the action should be confined within certain limits, but the lighting must be so arranged as to light the stage properly, and yet keep the lamps in such a position that the camera will not shoot into them.

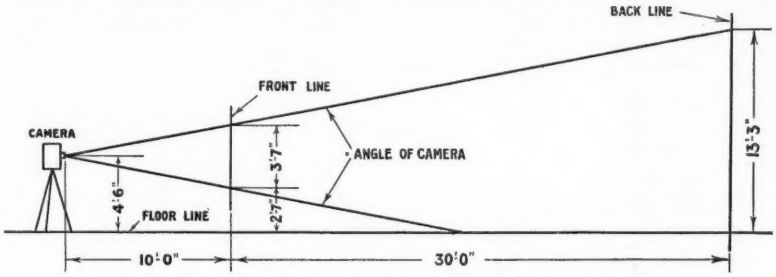


FIG. 1—Elevation of moving picture stage showing camera lines.

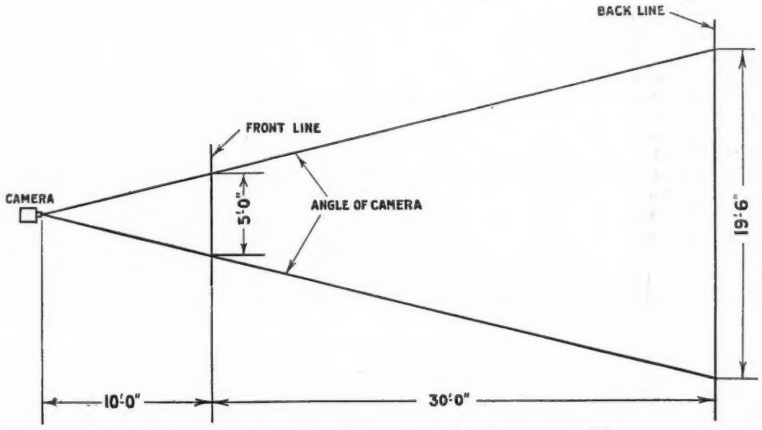


FIG. 2.—Plan of moving picture stage showing camera lines.

1 and 2 show the approximate lines along which a play is staged. All action must be confined within these lines, for if an actor oversteps a line, he is out of position, and moreover, if he should walk too far forward his legs and sometimes his head will be chopped off by the angle of the camera lens. It is thus seen that when working "close up" the action has to be carried on in a comparatively small space.

The importance of light is emphasised by the statement that no matter how good the scenario may be, or how well it may be worked up, the result of the efforts of the producer and actors will not register clearly and accurately on the film if the action is not properly lighted.

The most efficient way to light a stage either wholly dependent on artificial light or using it in conjunction with daylight is by means of Cooper-Hewitt lamps

arranged in banks, say, eight tubes. Each of these banks throws a mass of light upon the scene similar to that from a fair size window or skylight.

The Cooper-Hewitt lamp is particularly desirable for this class of work on account of the great actinic power of the light; for equal illumination, it being about the same as daylight. Also the fact that the light comes from a long tube in place of being concentrated in a small point, ensures thorough diffusion of the light and gives a lighting effect similar to daylight. The light blends with daylight, and where used in a daylight studio can gradually be added as the daylight decreases.

Lamps are frequently arranged in skylights for hanging from the ceiling to provide top light, and floor stands are added to take care of the side lighting and reinforce the lighting at special points to obtain the best effects. By properly arranging the lights around the sides of the stage and overhead, modelling effects can be produced which do away with flat pictures which are apt to result from improper lighting.

As an instance of the manner of lighting a studio for large stage work, we may take a stage about 32 ft. deep. In a typical installation of this type there are 208 tubes, 136 for overhead lighting and 32 for high side lighting, with 48 mounted in

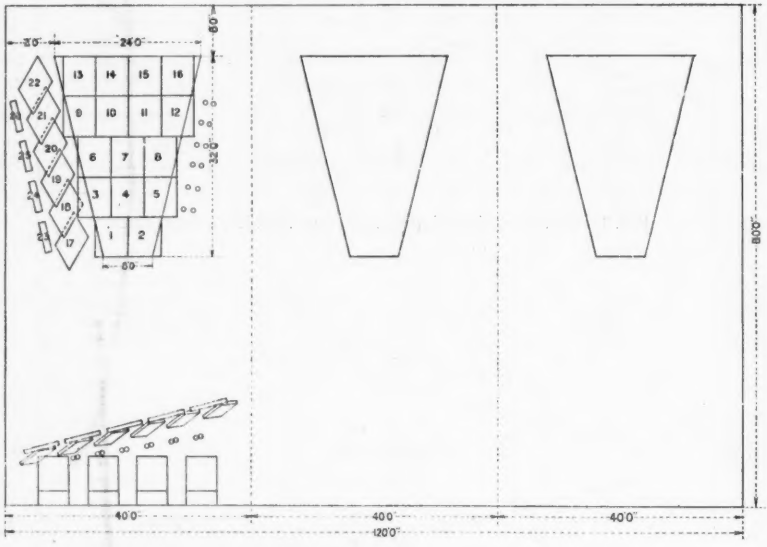


FIG. 3.—Arrangement of lamps for illumination of typical stage: two adjacent unoccupied stages are also shown.

⊙ indicates quartz mercury lamp. ▭ C.H. floor stand lamp.
▭ C.H. skylight frame.

Even with two or three hundred lamps on a stage there is very little glare, and no harmful effects are produced on the eyes of the actors. Furthermore, even with this large amount of light, the temperature of the stage is only slightly raised above the surrounding atmosphere. This is a most important point to be considered in taking pictures, and especially in fairly long scenes, as the fatigue produced by an excess of light will prevent the players from putting forth their best efforts.

floor stands for moving about to throw the light from one side and towards the front.

The overhead lamps are arranged in the following manner:—Eight tubes in two banks are hung at approximately 8 ft. over the front line, at an angle of about 30 degrees inclined toward the stage; back of these lamps are hung three banks of eight lamps, each at the same angle, and this idea is carried out so that at the back line there are four banks, at about 18 ft. above the stage, this fan-shaped method being essential to cover the stage.

On one side are four hanging banks which are inclined 45 degrees, throwing the light in on the stage. No lamps are placed opposite to these, for the reason that if the illumination was equalised the picture would photograph flat. The floor-stands are placed at various positions to get light in on the stage to light up spots where the top and side lighting do not reach and to produce artistic modelling.

The overhead lamps in this studio are all suspended from a trolley system which permits the lamps to be moved from one end of the studio to the other, and cover in this manner three different stages. By this method scenes can be set up on two stages while pictures are being taken on the third, and no time is lost between the taking of the scenes.

In addition to Cooper-Hewitt lamps a studio should have four or five large arc lamps, which can be used in conjunction with the tube lamps for spot lighting effects. Moreover, arc lamps are used for fireplace lighting, table lamps, and other special lighting effects.

A large studio may consist of as many as four stages completely lighted with Cooper-Hewitt lamps. Each stage is completely lighted, and no trolley system is needed for changing the position of the lamps. In other words, four different sets can be photographed at the same time, or while one or two sets are being taken, others can be set up, which eliminates lost motion, and there is no waiting for light at any time.

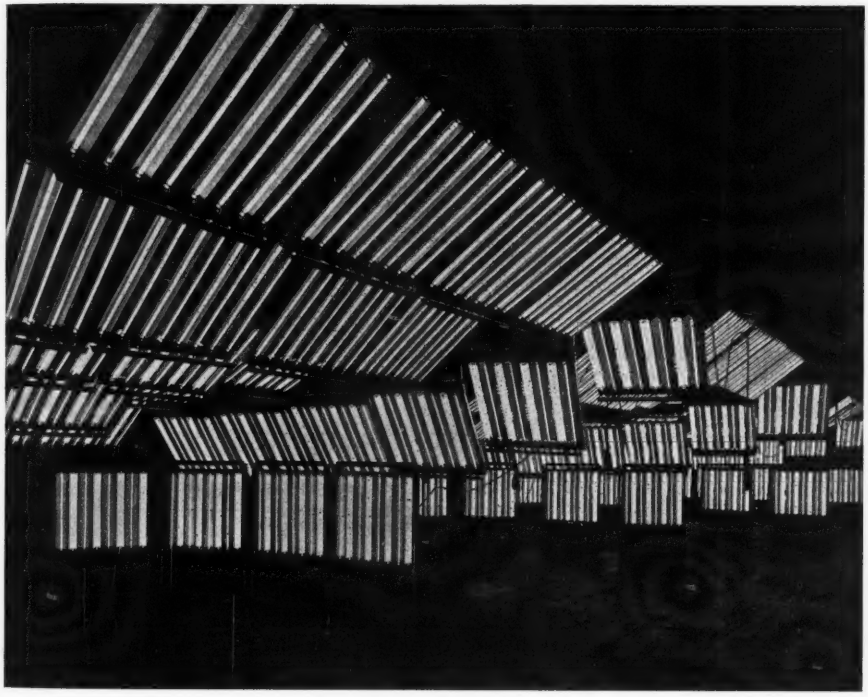


FIG. 4.—Showing massed mercury vapour lamps for illuminating scene in cinema studio.

The main advantage of lighting a moving picture stage with Cooper-Hewitt lamps, is primarily, the fact that pictures can be taken at the proper speed and at any time, day or night, with lighting effects that are equal to daylight. Moreover, the camera-man never has to make any change whatsoever in the aperture of his lens during the taking of a scene, as the quality and quantity of light is always the same. Passing clouds and the many changes in daylight values do not occur in an artificially-lighted studio, and pictures taken under Cooper-Hewitt light always show the same degree of clearness

and detail. Sometimes, in taking outdoor pictures, the same scenes have to be taken over and over again, due to the fact that the light was not just right. "Retakes" are not necessary in a studio with artificial lighting properly installed.

The high actinic value of the Cooper-Hewitt lamp is indicated in Figure 5 showing a spectrum of this light. It will be seen that there are practically four lines in the visible spectrum which stand out prominently—404, 436, 546 and 578 $\mu\mu$. Of these four lines twenty-five per cent. of the visible light is derived from 404 and 436 $\mu\mu$, which lie in the region where the ordinary film is most sensitive. It will be seen that the point of maximum sensibility is at about 404 $\mu\mu$, where the light from the Cooper-Hewitt lamp is particularly strong.

As the Cooper-Hewitt lamps used for this work require no carbons or trimming and the only cost is for replacing the tubes, which have an extremely long life, the maintenance cost is extremely low, the actual cost for maintaining tubes for this work averages from actual experience six shillings and sevenpence ($1.35) per tube per year.

On a large stage, the cost of lighting for taking 1,000 feet of film, which would mean about two days' complete work with the lamps on for about two hours, would amount to 31s. 6d. ($7.50) for current and 6s. 3d. ($1.50) for maintenance, or a total of 38s. ($9.00) for 1,000 feet, whereas the entire cost of the film may have run from £200 to £800 pounds, depending on the subject. In other words, the best lighting can be obtained on the average for less than one-half of one per cent. of the entire

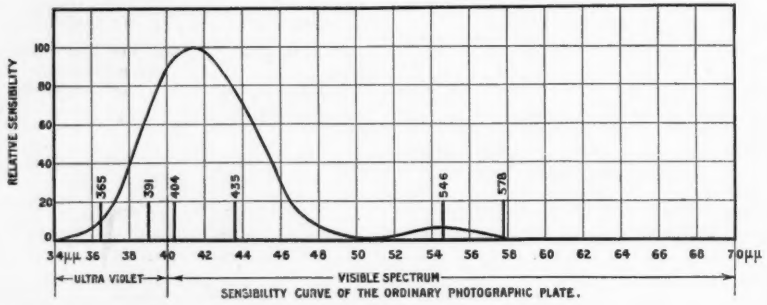


FIG. 5.—Sensibility curve of ordinary photographic plate and spectrum of mercury lamp (shown by numbered lines).

In figuring on the total illumination for a stage, it will be found that proper lighting can be produced by Cooper-Hewitt lamps with an expenditure of current of about 100 watts per square foot of floor space, that is, a small stage can be lighted with about 30 kilowatts, a medium size stage with 45 kilowatts, and a large stage with about 75 kilowatts. Stages lighted under these conditions will have a floor illumination averaging about 400 foot-candles. These figures serve as a useful guide for estimating purposes; it should, however, be borne in mind that, just as illumination intensities in domestic and industrial lighting vary over relatively wide limits, so they may also in the studio.

cost of the film. Considering the fact that some actors are paid £200 a week and over in salaries, or about £10 per working hour, every single minute of their time that can be saved by proper lighting is instrumental in reducing the total cost of the film.

Finally, proper photography reinforced by successful lighting will do as much to keep the "stars" before the public and build up a clientele for the film manufacturer, as will the engaging of new "stars" and the use of successful plays. The public is becoming more and more critical; and no play, no matter how good, and no "star," no matter how famous, will be able to draw unless the "Light" is good.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we are again extending the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

BLANCHARD LAMPS.

(For Field Hospitals.)

We have been informed that the **Blanchard Lamps (British) Ltd.** in Farringdon Road have been very busy with Government work lately; there was recently at the premises a large consignment of lamps ready to go off to the Admiralty for a very special use which we are not allowed to particularise.

Blanchard Lamps, as readers of THE ILLUMINATING ENGINEER are aware, utilise incandescent mantles with paraffin or kerosene and are entirely "self-contained"; consequently they can be utilised for emergency lighting, and as portable illuminants, and are readily transferred from one place to another.

The company is well to the fore also in all movements of the moment and have designed a special lamp for use in military field or other hospitals, which we illustrate.

The particular feature of this medical lamp is its portability and the fact that while sufficiently powerful to illuminate an apartment of good size (the lamp is of 100 c.p.) it is not too heavy nor too large to be held by an assistant while an operation is in progress. We would like to draw attention to the useful reflector attached to the lamp, with a view to concentrating the light, downwards—an important point which is not always sufficiently appreciated by makers of lamps of this kind. These lamps are neatly packed in special cases containing every possible extra accessory, so that their usefulness would not be curtailed by the thousand and one risks attendant on war service. A recent instalment was supplied to the Canadian Medical Division.

We are glad to hear that the question of the lighting of hospitals is receiving attention. Those who are engaged in supplying lamps for tnis purpose, which

are so vital in the alleviation of the sufferings of our soldiers, are doing indispensable work for the nation, no less than the men in the fighting line.

HARRY GUSTAV BYNG.

It is with great regret that we record the death of Mr. Harry Gustav Byng, third son of the late Mr. Gustav Byng, the founder and late Chairman of the General Electric Co., Ltd.

Mr. Byng was born in 1889. Educated at Harrow, he afterwards joined Faraday House, where he gained the Silver Medal for his year. He next entered Harvard University, passing his examinations with honours and becoming captain of the Association Football XI. After joining an exploring expedition into the less known parts of Canada, he returned to take up a responsible position with the General Electric Co., Ltd., in this country. At the outbreak of war he joined the Artists' Rifles and was subsequently gazetted 2nd lieutenant of the Second Border Regiment. He fell in battle, gallantly leading his platoon, near Festubert on May 16th. He was universally popular with his regiment and his commanding officer speaks of his death as a great loss to the battalion.

The news will be heard with keen regret by Mr. Byng's many personal friends in the electrical industry.

PERSONAL.

Mr. Haydn T. Harrison, who is well known to readers as a member of the Council of the Illuminating Engineering Society, has been appointed Lieutenant R.N.V.R. attached to H.M.S. Vernon in order to carry out certain special work for the Admiralty.

Mr. J. Scrivener has resigned his position of Director and Manager of Messrs. Krupka & Jacoby, Ltd., having been appointed to control the Sales Organisation of the "Z" Electric Lamp Co., Ltd., Southfields, London, S.W.

Mr. Scrivener's late co-Directors have given him, as a mark of their personal esteem, a gold watch, suitably engraved; also the Staff have presented him with a suit-case.

HALF-WATT FITTINGS.

Messrs. A. E. Podmore & Co. (34, Charles Street, E.C.) are well known for special work in connection with gas lighting and were the originators of a number of special forms of lanterns, lamp accessories and special shades. During a recent visit we were interested to find that the firm is also taking up the design of fittings for Half-Watt electric lamps. There is a great deal being done in this direction just now and as these lamps invariably require shading owing to their great intrinsic brilliancy, there should be a steady and increasing demand for appliances for use with them.

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Note.—The Bonds of the Corporation are accepted by all Departments of His Majesty's Government.

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THE EFFECT OF LIGHT ON COLOURED FABRICS.

SOME very interesting experiments on this subject are described in a recent report of the British Commercial Gas Association.

The object of these experiments was to investigate the effect of the light, the temperature, and the products of combustion of incandescent lamps, on coloured materials. A series of specimens of coloured fabrics were exposed to illumination of 20—40 foot-candles, the temperature being 75—80° F., and the CO_2 9—18 parts per ten thousand. Although these effects were considerably above the normal, no appreciable deterioration in colour could be found.

A second set of colours, exactly similar to those used in the first experiment, were placed in an opaque vessel into which no light could enter but which gave free access to the vitiated air. Next, specimens were hung up in a sealed jar of fresh air, and in a third experiment the fabrics were exposed in such a manner as to receive illumination and temperature but not the products of combustion. Subsequentlly a fourth set of colours was suspended in a jar of perfectly fresh air, the jar being sealed to prevent the access of products of combustion, and covered with a brown paper jacket to prevent illumination of the materials. All these experiments, which were designed to test any deterioration due to the effects of illumination, temperature and products of combustion, gave rise to no appreciable change in colour. An identical set of examples was also enclosed in a sealed jar and preserved in a dark and cool place so as to serve as a standard for reference. Finally a set of specimens was exposed to full daylight, but not to artificial light.

All these experiments were continued for a period of 90 days. In the case of the specimens exposed to gaslight, the exposure took place continuously for 24 hours; in the case of those exposed to the daylight, the degree of illumination of course varied with the natural conditions. The essential result was that the colours exposed to gaslight altered very little, while those which were exposed to daylight changed very materially. It would appear, therefore, that daylight rather than gaslight is mainly instrumental in causing the fading of colours. Presumably this is due to the well-known fact that daylight contains a considerable percentage of ultra-violet light.

LIGHTING AND VENTILATION.

LIGHTING and ventilation are twin subjects. It is well known that the shape of modern schoolrooms is determined almost entirely on the balancing of these two factors, and in most modern installations both have to be considered. Some of the most recent gas lamps, too, have a double function. They are specially designed, not only to illuminate the room, but to promote a current which carries away the vitiated atmosphere.

A report by the Joint Committee of Ventilation Research was presented by Mr. William Harrison, the research chemist, at the annual meeting of the Institution of Gas Engineers. The report contains particulars as to the volume of air moved by various gas-consumptions and also the results of tests on a variety of types of burners. It is interesting to know that upright burners are slightly more efficient than those of the inverted type.

It was considered that the subject dealt with in this report required fuller discussion. There is no doubt that the problems of ventilation and lighting of rooms are often correlated and will have to be considered together.